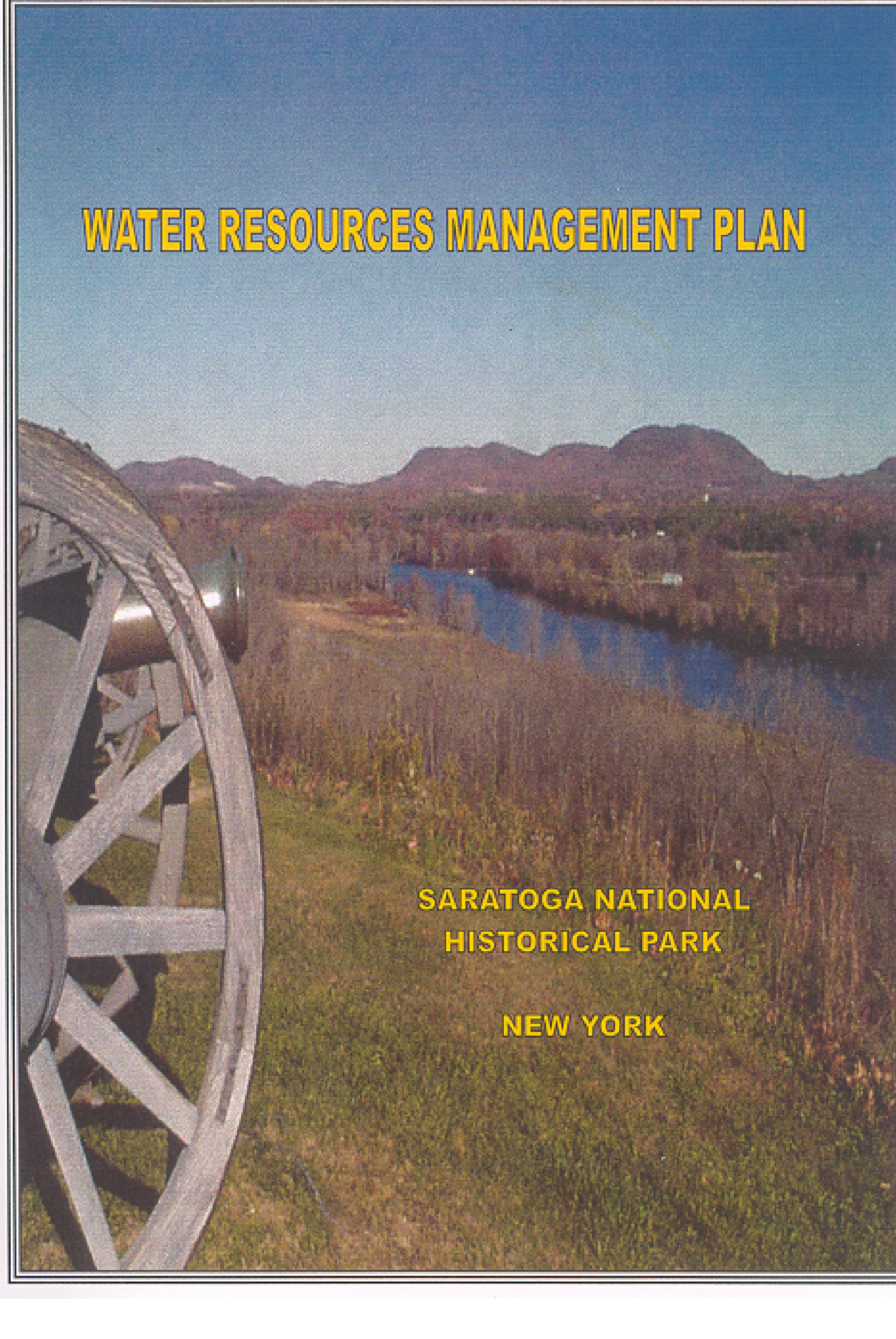
WATER RESOURCES MANAGEMENT PLAN



SARATOGA NATIONAL HISTORICAL PARK

NEW YORK

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EXECUTIVE SUMMARY

Saratoga National Historical Park consists of approximately 3406 acres along the Hudson River in the Town of Stillwater, New York (Saratoga County), approximately 30 miles north of Albany and 10 miles southeast of the City of Saratoga Springs. The park is a mosaic of cultural and natural resources making it necessary to integrate the preservation and maintenance of historic structures and objects, with the preservation of natural resources, cultural landscapes, and viewsheds.

Small, direct tributaries to the Hudson River — Kroma Kill, Mill Creek, American's Creek and Devil's Hollow drain Saratoga National Historical Park. Originating northeast of the park Kroma Kill occupies the largest drainage area and flows through the park as a third order stream. All of the Mill Creek drainage is contained within park boundaries. It enters the Hudson as a second order stream. American's Creek is the name given by the park to a small, first order stream entering the Hudson just south of the Mill Creek confluence with the Hudson. Devil's Hollow (locally used name) in the southern end of the park is a second order stream that flows through a hemlock-laden cascade with a gradient drop of over 100 feet. Devil's Hollow was historically called Great Fall Creek.

The park conducted its own water quality monitoring program in the late 1980s; however, this program was discontinued after only a few years of operation. At that time the quality of tributary waters was generally good. Compounding this lack of knowledge about the park's water quality is the continued residential growth within watersheds of the park. Potential nonpoint sources of pollution to park waters include: nutrient loading of nitrogen and phosphorus from residential wastes and fertilizers; road salt and auto exhaust by-product runoff from roads; gasoline and oil product contamination from residential runoff, and bacterial and infectious agent contamination from failing septic systems.

This Water Resources Management Plan has been developed cooperatively by the National Park Service's Water Resources Division and Saratoga National Historical Park to assist park management in the understanding and management of these resources. It provides an overview of existing resource condition, identifies water-related management issues, and develops alternatives that addresses resource issues and management in the park. This Water Resources Management Plan is complementary to, and consistent with, other exisiting park management documents, including general management plans and resources management plans.

Water-related resource issues discussed within this plan include:

- Development of a cost-effective water quality monitoring program;
- Water quality concerns at the Price Farm and Schuylerville dump sites;
- Abandoned water wells in the park;
- Beaver re-colonization of Mill Creek and other watersheds;
- Flooding of Route 4 by Old Champlain Canal;
- Adequacy of current potable water supply system; and
- Potential risk of zebra mussel colonization.

The Water Resource Management Plan further presents a number of management recommendations and provides one water-related project statement (Appendix A) that is recommended to address foreseeable water-related issues over the next decade. Project statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify the additional staff and/or funds needed to carry out the proposed action. They are planning tools as well as programming documents used to compete with other projects and park units for funds and staff.

INTRODUCTION

Water is often a significant resource in units of the National Park Service, either through support of natural systems or providing for park and visitor use. The National Park Service seeks to perpetuate surface and ground waters as integral ecosystem components by carefully managing the consumptive use of water and striving to maintain the quality and health of aquatic ecosystems in accordance with all applicable laws and regulations. Water resource inventory and monitoring activities are essential tools of park resource management.

This water resources management plan summarizes existing water resource information and identifies and discusses several water resources-related issues and management concerns pertinent to Saratoga National Historical Park. It is designed to serve as a management implementation plan to guide park water-related activities over the next 10 years. This water resources management plan is complementary to, and consistent with, other existing park management documents, including the Statement for Management (Saratoga National Historical Park 1992), General Management Plan (Saratoga National Historical Park in prep.) and the Resources Management Plan (Saratoga National Historical Park 1992). Additionally, the summary of water-related information and issues and the proposed management actions that address these issues can be incorporated into the park's Resource Management Plan.

LOCATION, SITE DESCRIPTION, AND LEGISLATION

Saratoga National Historical Park consists of approximately 3406 acres along the Hudson River in the Town of Stillwater, New York (Saratoga County), approximately 30 miles north of Albany and 10 miles southeast of the City of Saratoga Springs (Figures 1 and 2). The park is a mosaic of cultural and natural resources making it necessary to integrate the preservation and maintenance of historic structures and objects, with the preservation of natural resources, cultural landscapes, and viewsheds.

Saratoga National Historical Park was authorized by an Act of Congress on June 1, 1938, making it one of the earliest of the nation's historical parks. The park derives its significance from the decisive role the area played in the American Revolutionary War, and, more specifically, the British Campaign of 1777. As a major segment of that years activity, British General John Burgoyne brought an army south from Canada along the Lake Champlain-Hudson River route with the intention of occupying Albany. The Americans engaged Burgoyne in two battles and a seige in the Saratoga area, stopping him short of his goal, and forcing the surrender of his army. This victory provided the American Army with a much-needed victory, and forced the British to concentrate their military strength on the southern colonies. Additionally, the American victory at Saratoga, combined with the British failure to defeat General Washington's army in Pennsylvania, stimulated France's participation in the war.

The park represents a particularly rich blend of significant cultural and natural resources. The landscape of Saratoga was a unique setting for an 18th century battlefield, and may be the only one of its kind that is preserved in Europe or North America (Snow 1977). The relatively unspoiled landscape, managed for historic accuracy, portrays the story as well or better than any other site of the Revolutionary War in the national park system. Significant cultural resources include the Freeman and Barber farm fields where the two battles occurred, as well as several other 18th, 19th and 20th century sites. The restored John Neilson and Philip Schuyler houses, and the Saratoga Monument are the most prominent structures. Portions of the Old Champlain Canal (constructed circa 1820s) remain nearly intact.

Figure 1. Regional location map for Saratoga National Historic Park (modified from National Park Service 1997).

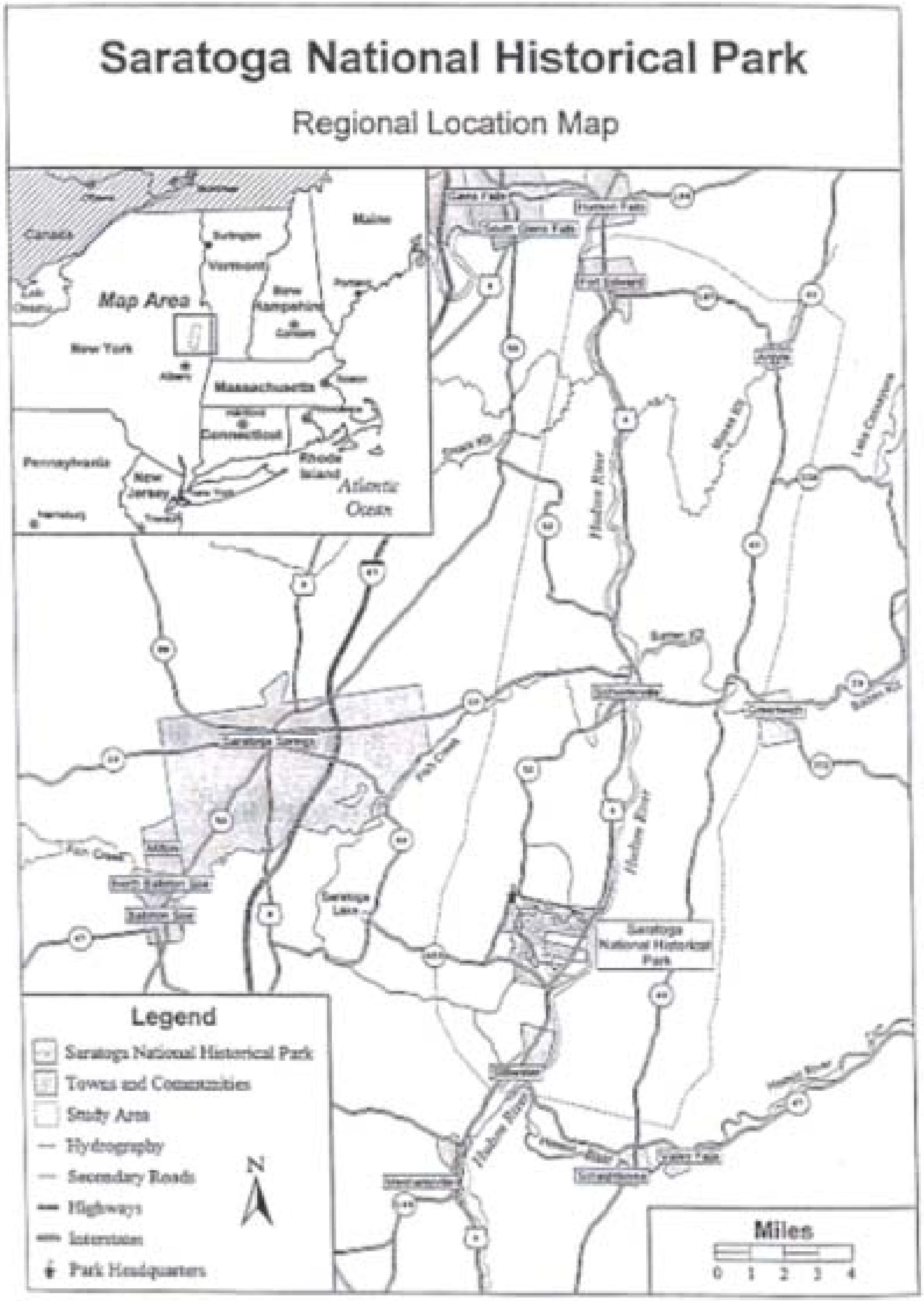

Figure 1. Regional location map for Saratoga National Historic Park (modified from National Park Service 1997).

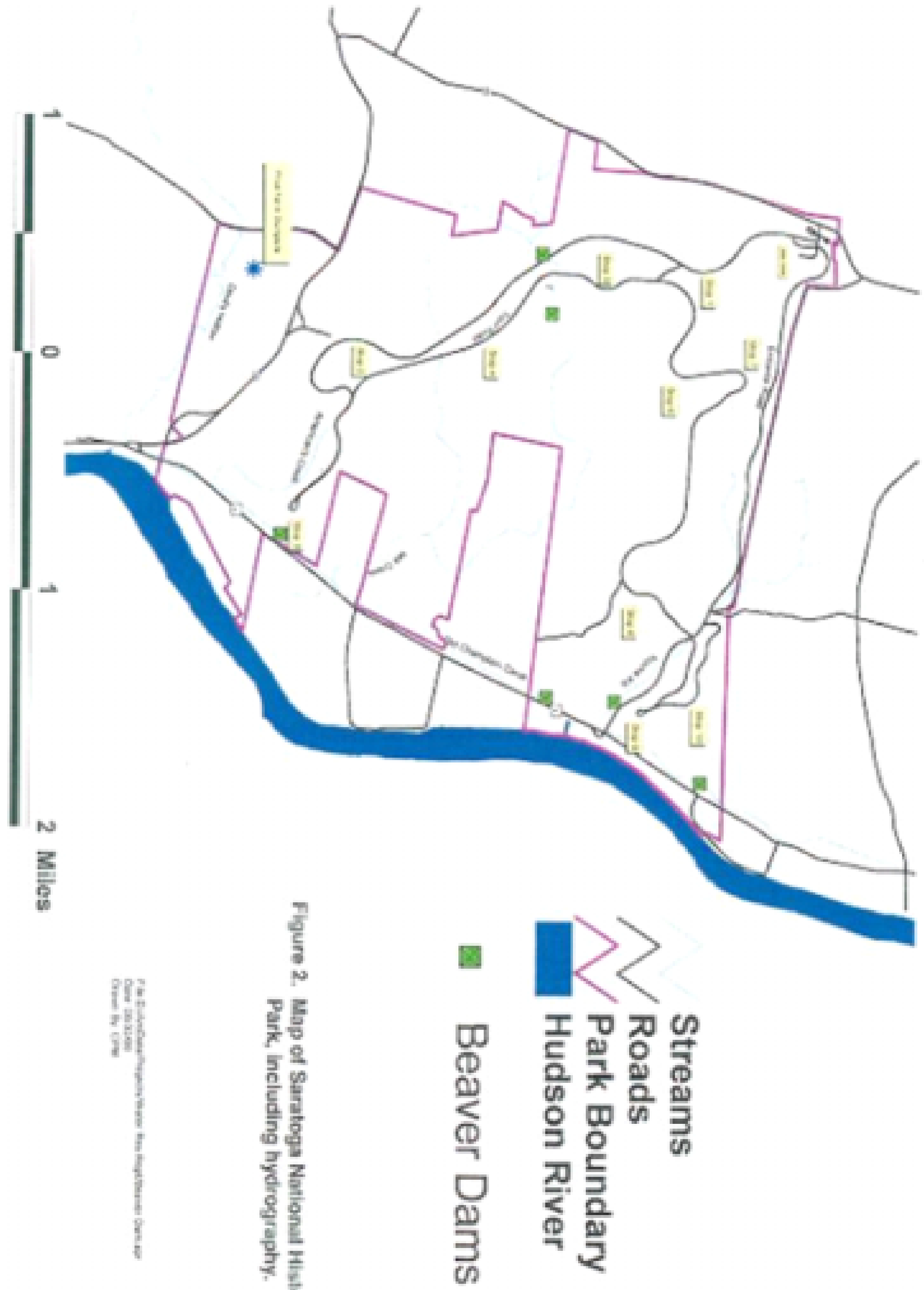

Figure 2. Map of Saratoga National Historic Park, including hydrography.

There are three detached areas of the park just to the north of the battlefield unit. The Schuyler House, in the Village of Schuylerville (Figure 1), was the home of General Phillip Schuyler both before and after the battles. The British burned the original house and its outbuildings to keep the Americans from using them for cover during the attack. The present home, erected in 1777 shortly after Burgoyne's surrender, was the center of Schuyler's extensive farming and milling operations. This unit, bounded on the north by Fish Creek and the east by the Hudson River, totals approximately 30 acres.

In the Village of Victory (just west of Schuylerville; Figure 1) the Saratoga Monument commemorates Burgoyne's surrender on October 17, 1777. Completed in 1887, the 1 55-foot memorial stands in what was Burgoyne's camp during the waning days of the campaign. This unit totals approximately 3 acres within a residential area.

The Victory Woods is a 23-acre parcel of land in the Village of Victory that was deeded to Saratoga National Historical Park in 1974, by the A. L. Garber Company (formerly the Victory Manufacturing Company). This tract of land had been part of the camp occupied by the British in October of 1777, after their retreat from Bemis Heights. The events that took place were an important component of the Burgoyne campaign. What makes this site unique is that earthworks remain largely undisturbed. The only exception to the disturbance was a water supply system built by the Victory Mills factory, sometime after the turn of the century. The system consisted of a water tank 40 feet high and 20 feet in diameter with various pipes and fittings. The water tower and some of the pumps and pipes were removed in the early 1990's. The site of the water tower, the spillway, and some of the pump stations and pipes remain today. No other development exists on this parcel nor is it presently interpreted.

PARK MANAGEMENT OBJECTIVES

In describing the resources within the park, the Statement for Management (Saratoga National Historical Park 1992) emphasized that cultural resource management is paramount. The preservation of the park's cultural resources and the cultural landscape are the two primary resource management objectives. Natural resource management is concerned primarily with the preservation of biological diversity through the conservation of plant and animal populations, inventory and monitoring of park natural resources to provide information for preservation, and restoration of mature forests within the context of the cultural landscape.

LAND USE

The development of the current landscape can be divided into four phases. The first phase, before European settlement to September 1777, produced the original land allocations and forest clearings that shaped the actual battlefield conditions. The second phase, from 1777 to about 1782 saw huge changes as a result of the battles. A third phase (1782 to 1880) established overall agricultural use patterns through major land clearance. The fourth phase, from about 1925 to present, constructed the present landscape where land development interacted with natural cover and existing agricultural use patterns.

With the end of the Revolutionary War, the area experienced increased land leasing. Estimates of the land cleared in Stillwater in the 1820s range from 50 to 60 percent. The major regional effort to improve shipping by constructing canals led in 1823 to the opening of the Champlain Canal along the Hudson River, which provided shipping form Albany to Lake Champlain. (Two segments of the Old Champlain Canal run through and are owned by the park, one on the east perimeter of the battlefield and the other through the grounds of the Schuyler House). The canal's completion spurred development of the region. Between 1830 and 1870 farmers cleared most of the remaining forests in the area; by 1870 ninety percent of the forests had been cleared. The overall picture of the battlefield during this time period is of cleared land with orchards near the farm sites and scattered woodlots.

By 1927 the proportion of land in open, cultivated fields had dropped to 80 percent from more than 90. By 1940 photographs of the park show mainly open fields with scattered forested-areas and hedgerows dominated by elm trees. In 1949 the park historian, Charles Snell, documented the ground cover at the time of the battles. Park management has since used this information in its efforts to re-establish those conditions, e.g. allowing fields to revert to forest and cutting wooded areas to maintain as open fields. By 1991 the overall pattern of forest and cleared area proposed in the historic base map was generally well established, representing a major change from the predominately open vegetation of 1950. Only 29 percent of the land is maintained as open fields, while 57 percent is in forest. Presently, open areas are maintained by mowing or prescribed burning, with a few peripheral tracts being leased to locals for cutting of hay.

Of the approximately 3406 acres within Saratoga National Historic Park, about 2,856 acres (84 percent) are owned by the NPS. State and local governments own about 83 acres and the remaining 453 acres are in private ownership. Eight tracts are scheduled for fee acquisition with uses ranging from highway maintenance yards to abandoned canals, fields, and right of ways. Six tracts are scheduled for easements; uses are residences or woods and farming.

Three towns border the park. The main battlefield unit lies within the Town of Stillwater and across the Hudson River from the Town of Easton in Washington County. Just to the north of the battlefield unit is the Town of Saratoga. There are three detached areas of the park within this town.

While these towns are presently rural in character, population and development trends (e.g., Saratoga County is one of the fastest growing counties in New York) suggest this to be short-lived. All three towns recognize the need to provide for rural/agricultural use in the land surrounding the park. Zoning ordinances are in force in Stillwater and Saratoga, but protection provided to adjacent lands is minimal. For example, zoning regulations in the town of Saratoga classify the land surrounding the park as rural. A special permit is required under this classification for such activities as agricultural businesses (distinct from farming), schools, recreation, saw mills, garden shops, building supply companies, restaurants, auto body shops, and mining. The low-density residential (Ri) zoning in the Stillwater ordinance provides for boarding homes, public and semi-public uses and small animal hospitals or kennels after site plan review. Historically, the demand for special use permits near the park has been low. As the town grows, however, such requests may increase.

SITE VISITATION

The park is visited by just over 150,000 persons annually with most of that occurring in the June through October period. The tour road is open usually from April 1 to mid-November, depending upon weather conditions. The Schuyler House is open during the summer months only and receives from 7,000 to 10,000 annual visits. The Saratoga Monument is currently closed for renovations and will reopen in 2001.

Saratoga County is steadily moving from rural to suburban in character. This rise in population density is increasing the demand for recreation opportunities in open spaces. The main battlefield unit is already experiencing problems with visitor use conflicts and resource damage associated with hikers, bikers, and horseback riders. More frequently, increasing numbers of local residents use the park for walking, bicycling, horseback riding, wildlife watching, and crosscountry skiing. Forty-five percent of all visitors are from the local communities. Nearly 20 percent of all visitors have been to the park 10 or more times. Recreational trends in the

Northeast are predicted to continue increasing for the upcoming years, especially for such activities as hiking, biking, and cross-country skiing (Warnick 1995).

EXISTING RESOURCE CONDITIONS

WATERSHEDS, HYDROGRAPHY AND CLIMATE

The 13,400-square mile Hudson River basin lies almost entirely within New York State, but includes parts of Vermont, Massachusetts, New Jersey, and Connecticut. About 62.3 percent of the Hudson River Basin is forested, 24.9 percent is agricultural land, 7.8 percent is urban and residential land, 2.6 percent is open water, and 2.4 percent is classified as "other." The basin is divided into three parts, the upper and lower Hudson River and Mohawk River basins.

The upper Hudson River basin (drainage above the confluence of the Hudson and Mohawk rivers) has a drainage basin area of 4,590 square miles. Of this total, 3.4 percent is under urban land use, 15 percent is under agricultural land use and 76 percent is forested. Most of the upper Hudson River basin is in the Adirondack Highlands physiographic province with the rest in the Taconic Highlands and Hudson Valley (Will et al. 1982). The source of the Hudson River is Lake Tear of the Clouds, a small lake in the Adirondack Mountains 4,322 feet above sea level (asl). The river flows south-southwest out of the mountain region through primarily forestland. At Hudson Falls, the river includes flow from several tributaries and has dropped to an elevation of about 200 feet asl. From Hudson Falls to Albany, the river is maintained for commercial traffic at a depth of about 12 feet. South of Hudson Falls the river flows through forest and farmland to its confluence with the Mohawk River near Troy.

Small, direct tributaries to the Hudson River — Kroma Kill, Mill Creek, American's Creek and Devil's Hollow (Figure 2) drain Saratoga National Historical Park. Originating northeast of the park Kroma Kill occupies the largest drainage area and flows through the park as a third order stream. All of the Mill Creek drainage is contained within park boundaries. It enters the Hudson as a second order stream. American's Creek is the name given by the park to a small, first order stream entering the Hudson just south of the Mill Creek confluence with the Hudson. Devil's Hollow (locally used name) in the southern end of the park is a second order stream that flows through a hemlock-laden cascade with a gradient drop of over 100 feet. Devil's Hollow was historically called Great Fall Creek (Neilson 1924). The USGS topographic map for the park shows these streams as unnamed.

The climate of the area is humid continental, characterized by long cold winters, short warm summers, and moderately heavy precipitation. Normal monthly temperature ranges from a low of about 20° F in January to a high of about 70° F in July. Precipitation is fairly evenly distributed throughout the year, although ordinarily it is slightly greater during the summer than in other seasons. The mean annual precipitation is 37.82 inches.

The past condition of park air quality has been listed as acceptable with marginal influences from industrial pollution (Saratoga National Historical Park 1993). Saratoga National Historical Park is a class II air quality area as defined by the Clean Air Act. Aside from ozone monitoring conducted by the state, no park-specific acid deposition or air quality data have been collected. The impact of pollutants from sources in the neighboring Saratoga Springs area, or other distant sources on cultural and natural conditions is unknown. The effects of acidic deposition on park monuments or waterways is unknown at this time.

FARM PONDS AND SPRINGS

Within the park there were several ponds associated with farms that were established after the battles. Most of these ponds have been subsequently reclaimed. However, two small farm ponds, one located on the former Burdyl Farm and the other on the former Davidson property, are extant. At present neither pond is readily accessible to the public, but the issue of current and future visitor use patterns and interpretive trail networks is being addressed by the park in its general management planning effort (Saratoga National Historical Park *in prep.).* If the presence of these ponds becomes problematic either for visitors or for their intrusion on the cultural landscape, they may be proposed for reclamation. Such an effort would require compliance with the National Environmental Policy Act as well as securing the requisite environmental permits.

Two springs at the southern end of the park are potentially historic in nature and may well have provided freshwater to soldiers in the American encampment. One spring is located in the backyard of the Kussius house, which is slated for removal in the near future. During reclamation of the house site, care should be taken to avoid any disturbance of the spring. The other spring located adjacent to the Baker residence was dug out by the Bakers and made into a pond. The National Park Service owns the Baker residence through a lifetime occupancy agreement with the family. Upon transfer to the park, the house is slated for removal in order to protect the historic landscape. At that time a determination will be made to ascertain the feasibility and appropriateness of converting the present pond back to the historically significant spring.

Another spring is located to the northeast of Tour Stop 8 (Burgoyne's Headquarters). This spring, although not readily accessible to the public shows signs of erosion associated with visitor use. There is also evidence of a previous impoundment, perhaps as a drinking water source for pastured cattle. It is reasonable to assume this spring was flowing during the British encampment and may have influenced the decision to establish the British army's headquarters here. Because of its potential historical significance, the use of this spring should be monitored and park management alerted to any problems.

On the entrance road is the DeCoteau Spring. This developed spring flows from a pipe into a roadside ditch and under the entrance to the Kroma Kill.

The locations of all known springs in the park are depicted in Figure 13.

CULTURAL SIGNIFICANCE OF WATER RESOURCES OF THE PARK

The Hudson River and its tributaries have played a prominent role in the growth and development of the region. The river was used in colonial days as the primary transportation corridor between Albany and points north. Both armies (Burgoynes and Gates) relied upon the river as a means of transportation, supply and communications. Associated with both encampments were respective bridges built of boats to provide access to the eastern shore of the Hudson. Both armies encamped along the rivers banks and fortified their positions and roads.

The Crummah (Dutch corruption meaning crooked) or Kroma Kill and Mill Creek have played an integral part in the history of the area. The earliest settlers built mills along the banks of these streams enabling them to have a place to grind their corn, wheat etc., and have sawn wood for building. Ezekeil Ensign built mills on the Crummah Kill or Wilbur Basin Creek in the 1770's.

Historical accounts make reference to Burgoyne's British troops using a gristmill on the Kroma Kill during the period between the two battles. Fones Wilbur and one of his brothers were local millwrights in the 1700's and there are references to mills they built in the vicinity as weIll as other mills in Glens Falls.

The Champlain Canal, connecting the city of Troy to Lake Champlain, was completed in 1823. By 1825, the Erie Canal was completed and "canal mania" swept the nation. The Champlain canal ran along present Route 4 and connected the adjoining farm roads by bridges. Small enterprises flourished with the advent of the canal. Lumber, coal, agricultural products, marble, granite and sand were some of the main cargoes carried by canal boats to the distant markets in New York City and beyond. The blacksmiths at Bemis Heights and Wilbur's Basin were kept busy shoeing mules, used to pull the boats along the canal.

Decoteau Springs

Wilbur's basin, named after the Wilbur family and located at the confluence of the Kroma Kill and the Hudson River, was important as a turn-around for canal boats and as a place to load and unload goods at its docks. A thriving community of mills operated and flourished on the banks of this stream, including a sawmill, gristmill, plaster mill, and salt mill (from the will of Daniel Smith). The products from the mills were shipped down the stream by flat-bottomed barges to the canal via the turning basin and then sent to market. The Wilburs were one of the first families to establish a store in the area. Wilbur's Basin was a busy shopping destination as it had line barns, a blacksmith shop, grocery, and at one time a post office. Mules were housed overnight in line barns. The Great Storm of October 4, 1869 wrecked havoc on these resources. "At Wilbur's Basin a 7-foot canal break occurred and the mill dam gave way destroying Dr. Smith's gristmill, sawmill, and plaster mill (Asa Fitch's journal)." Behind the dam was a large pond that was used to supply ample power. In the winter skating was a popular pastime on the pond. This pond was often referred to as a "lake of unrivalled beauty."

An ancillary role of the canal was its use in the transportation of slaves along the Underground Railroad. The local Quakers had a large role in protecting and guiding these slaves to the north.

The Wilburs and many other families in the vicinity of the park were Quakers. The canal also presented many dangers, especially to the children who were taught to shun the towpath, the rough drivers, and the mules who had reputations as kickers.

By 1915, the original Champlain Canal was abandoned and the new Champlain Barge Canal opened. In 1976 the Champlain Canal was nominated to the National Register of Historic Places.

TOPOGRAPHY, GEOLOGY, SOILS AND VEGETATION

Heath et al. (1963) divided the park and vicinity into two topographically distinct areas. West of State Highway 32 (Figure 3), the area consists of low hills elongated in a northeast-southwest direction, alternating with broad, relatively flat-bottomed valleys. The altitudes of the hills range from about 400 feet above sea level (asl) in the northwestern corner of the park to more than 600 feet asl a few miles west of the park. The floors of the valleys generally range in altitude from about 300 feet asl near State Highway 32 to 450 asl a few miles west of the park.

Old dam at Wilbur Basin

East of State Highway 32 the area consists of two terraces and the floodplain Ot tne Hudson River. The upper terrace ranges in altitude from about 260 feet asl to 300 feet asl. It is generally less than 0.5 miles wide and its surface is relatively irregular. Some of these irregularities are due to the presence of uncovered bedrock hills forming the terrace. However, many of the irregularities are doubtless due to stream erosion. The upper terrace is separated from the lower terrace by a gentle slope. The lower terrace ranges in altitude from about 230 to 240 feet asl. The surface of the lower terrace slopes very gently toward the east. The steep-sided, V-shaped valleys that have been cut by streams crossing the lower terrace are one of the most striking topographic features in the area. The lower terrace is separated from the floodplain of theHudson River by a steep well drained scarp more than 100 feet high. The floodplain ranges from 0.1 too.5 miles in width west of the river from Kroma Kill south to Mill Creek. The altitude of the floodplain ranges from 90 to 100 feet.

Saratoga County is underlalin by two distinctly different types of rock. Most of the surface is composed of a layer of unconsolidated deposits ranging in thickness from a few feet on some hills to more than 100 feet in parts of the lowlands adjacent to the Hudson and Mohawk rivers. The layer of unconsolidated deposits is underlain by consolidated rock (bedrock) thousands of feet thick. The generalized bedrock geology of the park is primarily composed of sedimentary rock dating from 440 to 505 million years. Ordovician-age material such as limestones, sandstones, shales and slates dominate the park and surrounding areas. One feature of the park unique to this area is Devil's Hollow, a deeply eroded shale gorge in the southern portion of the park. Depths of the gorge range from 5 to approximately 80 feet, where an intermittent stream cascades over occasional, shale-based waterfalls.

No human-caused geologic disturbance has occurred in the park since the late 1930s to early I 940s when surface sand mining was active on lands within the park boundary.

The soils of the park are dominated by silt-loams/clays and produce site-specific variations in park vegetation. This soil type is subject to landslides as documented by case incident reports and resource management memoranda of 1987, 1989, and 1990 on file at the park. Small landslides (up to ¾ acre) have taken place in drainages throughout the park. Clayey-based soils retain large amounts of water in the spring and occasionally shift 5 to 10 feet down the hillside. Soils in the western part of the park are rocky and fairly well drained, while those in much of the dissected topography through the middle part of the park are poorly drained or only fairly well-drained, with slow permeability. Some soils on dune sands are very well drained, with high permeability.

Old Champlain Canal

The soil survey of Saratoga County (U.S. Department of Agriculture 1995) maps and describes the following soils occurring in the area encompassed by Saratoga National Historic Park:

> Berkshire loam, steep, very bouldery — This very deep, well-drained soil formed in stony glacial till. It occurs on mountainsides, ridges, and other convex landscapes in the higher elevations of the Adirondack foothills. Surface runoff is rapid with a moderate permeability and a severe erosion hazard.
>
> Bernardston silt loam (3 types) — This is a very deep, gently sloping to moderately steep, well-drained soil formed in glacial till which has a dense substratum. It is on the top or sides of hills in glacially modified uplands. Surface runoff is rapid with a moderate permeability a slight to severe erosion hazard (depending upon type).

Hudson silt loam (3 types) — This very deep, gently sloping to strongly sloping, moderately well-drained soil formed in water deposited material high in clay. It is an old lake plain. Surface runoff is rapid with a moderate to moderately slow permeability and moderate to severe erosion hazard.

Limerick-Saco complex — This unit consists of very deep, poorly drained Limerick soils and very deep, very poorly drained Saco soils. They are formed in recent alluvium on floodplains. Surface runoff is slow with a moderate permeability and slight erosion hazard. Madalin mucky silty clay loam — This very deep, nearly level, poorly drained to very poorly drained soil formed in water deposited silt and clay. It is in depressions on old lake plains. Surface runoff is slow to ponded with a slow permeability and a slight erosion hazard.

Manlius-Nassau complex (2 types) — This unit consists of moderately, well drained to excessively well drained Manlius soils and shallow, somewhat excessively drained Nassau soils. Surface runoff is medium to rapid with moderate permeability and moderate erosion hazard.

Nunda silt loam — This very deep, gently sloping, moderately well-drained soil formed in a silty mantle and the underlying glacial till. It is on the tops and sides of hills on till plains. Surface runoff is medium with a moderate permeability and slight erosion hazard.

Oakville loamy fine sand (3 types) — This very deep, predominately moderately well drained soil that formed in water sorted sand. It is on glacial outwash plains, lakeplains and beach ridges. Surface runoff is very slow to medium with a rapid permeability and slight to moderate erosion hazard.

Pittstown silt loam — This very deep, gently sloping, moderately well drained soil formed in glacial till which has a dense substratum. It is on the top and sides of hills in glacially modified uplands. Surface runoff is medium with a moderate permeability and slight erosion hazard.

Rhinebeck silt loam (2 types) — This very deep, nearly level, somewhat poorly drained soil formed in water deposited silt and clay. It is on glacial lake plains and upland areas. Surface runoff is slow to medium with a moderately slow permeability and slight erosion hazard.

Scarboro mucky loamy sand — This very deep, nearly level, very poorly drained soil formed in water sorted sand. It is in depressions on glacial outwash and lakeplains. Surface runoff is very slow to ponded with a rapid permeability and a slight erosion hazard.

Sun silt loam — This very deep, nearly level, poorly drained to very poorly drained soil formed in glacial till which has a dense substratum. It is at the base of hills, along streams, and in slight depressions on till plains in uplands. Surface runoff is very slow to ponded with a slow permeability and a slight erosion hazard.

Teel silt loam -- This very deep, nearly level, moderately well drained soil formed in recent alluvium. It is on floodplains along rivers and large streams. Surface runoff is slow with a moderate permeability and slight erosion hazard.

Tioga fine sandy loam — This very deep, nearly level, well drained soil formed in recent alluvium. It is on floodplains. Surface runoff is slow with a moderate to moderately rapid permeability and slight erosion hazard.

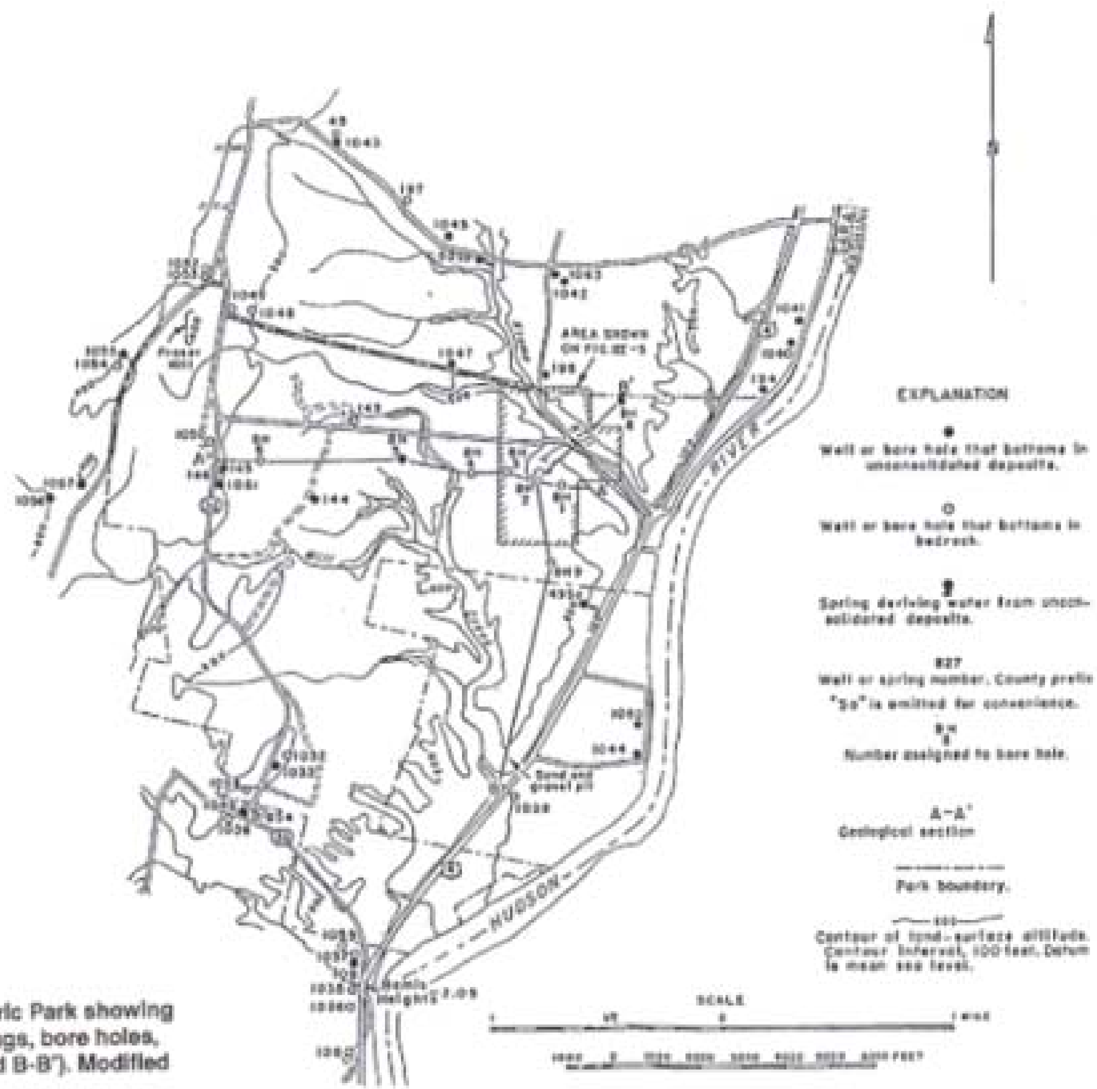

Figure 3. Map of Saratoga National Historic Park showing location of selected wells, springs, bore holes, and geologic sections (A-A' and B-B'). Modified from Heath et al. (1963).

Wareham loamy sand — This very deep, nearly level, somewhat poorly drained soil formed in water sorted sand. It is on glacial outwash plains, lakeplains and deltas. Surface runoff is slow with a rapid permeability and slight erosion hazard.

The park occurs within the transition zone between the Oak-Chestnut region and the Hemlock-White Pine-Northern Hardwoods region of the eastern deciduous forest. Deciduous trees characterize most of the mature forests of the region. Hemlock *(Tsuga canadensis)* is common in the steepest ravines on the north-facing slopes, whereas a mixture of hardwood species dominate upland and south-facing slopes. White pine *(Pinus strobus),* elm *(Ulmus americana),* and clones of big-leaf aspen *(Populus grandidentata)* are the first trees to colonize most abandoned old fields, with white pine and aspen in better-drained sites and elm in poorly drained sites (Russell 1995). A survey of the vascular flora of the park was conducted from 1987 to 1990 (Stalter et al. 1993).

Vegetation plays a prominent role in the interpretation of the park. The historic configuration of the fields and forests was important in the overall battle strategy of 1777. The sequence of the park's land acquisition and land use history has produced a mosaic of old field, shrub land, and forest communities. Current vegetation is considered an integral component of the cultural landscape.

GROUND WATER QUANTITY AND QUALITY

Heath et al. (1963) conducted intensive field investigations of the ground water resources of Saratoga National Historical Park. Although dated, this study remains the seminal work on ground water in the park. The following discussion is a summary of their work.

Bedrock based water occurs in openings along faults, joints, and bedding and cleavage planes. Although numerous in outcrops, most openings are probably too small to allow much water movement. Therefore, drilling below 300 feet usually does not increase the yield of wells, unless the well penetrates a more permeable formation where bedrock is crushed.

The number and size of openings penetrated by bedrock based wells determines their yield. Generally speaking, the yield of bedrock based wells is relatively low. The yield of Saratoga county wells drawing from shale averaged approximately 9 gallons per minute (gpm). The average depth of bedrock wells in the vicinity of the park was approximately 125 feet.

Layers of most unconsolidated deposits, including, from oldest to youngest, till, sand and gravel, clay, and sand are of Pleistocene age except for 20-foot thick layer (alluvium) that was deposited on the Hudson River floodplain in Recent time.

Figure 4 shows the location of the principal unconsolidated deposits in the park, based on the geologic sections shown in Figure 3. The principal unconsolidated deposit, extending westward from the Hudson River to about the 300-foot contour line, is clay. This clay was deposited Lake Albany, a glacial meltwater lake (Woodworth 1905). Much of the Hudson River area in Saratoga County is underlain by silt and clay contained in this lake. The northwestern corner of the park is underlain by till. On the terrace bordering the Hudson River floodplain a thin deposit of sand covers the clay. This sand is of late Pleistocene age and was formed during the final stages of Lake Albany.

The youngest unconsolidated deposit in the area is the alluvium deposited on the Hudson River floodplain during times of flood. This alluvium consists of both fine- and coarse-grained sediments.

A test-boring program in the park in 1958 determined the physical characteristics and extent of different unconsolidated deposits (Figure 5). The program was limited to the northern part of the park because the studies to that time indicated that the surficial sand deposit underlying the northeastern corner of the park was the best source of water readily available. The following discussion of the different deposits is based on the work in the northern part of the park but the description of the deposits and their water-bearing characteristics are applicable to these deposits elsewhere in the park.

The oldest unconsolidated deposit in the northern part of the park is till which directly overlies bedrock, where present. Above approximately 300 feet in elevation (includes most of the western part of the park) till is the primary unconsolidated deposit. Few test bore holes penetrated till; therefore, it appears that below 300 feet in elevation till occurs as discontinuous masses, if present at all. This till is composed of a large percentage of clay-size and silt-size particles derived from the shale underlying the area. Where the weight of the ice compacted the till, it is dense, difficult to drill through and called “hardpan.” Till ranges in thickness from zero at bedrock outcrops to more than 50 feet, but generally less than 25 feet thick.

The till characteristically has low porosity and permeability resulting from poor sorting and high clay content. Sustainable water quantities from till can be obtained only from large-diameter wells that have large areas (for water infiltration) and volumes (for the storage of water between periods of pumping). The most common diameter of dug wells is about 3 feet but one dug well in the park, well Sa 1065, was reportedly 16 feet in diameter (Figure 5). Based on experience elsewhere, the yield of most till based wells is probably only a few hundred gallons a day.

The lowermost stratified deposit in the park consists of sand and gravel that is exposed in a pit 100 feet north of the point where US Highway 4 crosses Mill Creek. This is the only known occurrence of this deposit in the area. Its thickness is unknown because the bottom of the sand and gravel is not exposed.

No wells are known to draw from the sand and gravel deposit in or surrounding the park. The overlying clay appears to restrict the downstream movement of water into the deposit. Moreover, because of the relatively high permeability of the deposit and its dissection by streams, any water percolating through the overlying clay readily drains into Mill Creek or into the Hudson River valley. This deposit should not be considered a potential water supply source.

In the northern part of the park, the lowermost stratified deposit consists of the clay that was deposited in Lake Albany. Clay appears to be the only unconsolidated deposit in the area occupied by the upper terrace. On the lower terrace a thin layer of sand was deposited when the waters of Lake Albany receded covers the clay.

Although not a potential source of water in the park, the clay influences the occurrence of water. It impedes water percolation, thus where clay forms the surficial deposit, most precipitation either runs off to streams or stands on the surface until evaporated. On the lower terrace clay serves as an impermeable bottom to the sand deposit.

The surficial sand deposit (thickness ranges from 1 to 2 feet to more than 25 feet) appears to be the only important aquifer in the unconsolidated deposits in the park. In fact the current water supply for the park comes from this deposit (Figure 5). Water occurs in this deposit under watertable conditions. Precipitation is the sole source of recharge to the aquifer. However, only a portion of the total precipitation reaches the water table. Water that reaches the water table moves under the influence of gravity to areas of discharge such as streams, springs, and seeps along valley sides.

Unconsolidated deposits cover the Hudson River valley except where bedrock crops out. These deposits range in thickness from zero (at outcrops) to more than 100 feet. Information obtained from well logs indicates that these deposits consist largely of sand and silt that was deposited in Lake Albany. The uppermost deposits are sand, silt, and clay (together termed alluvium) that have been deposited by the river in Recent time.

Unconsolidated deposits of the Hudson River valley that consist of sand or sand and gravel in direct contact with the Hudson River are probably capable of supplying large quantities of water. One well yielded 60 gallons per minute; others were probably less than 15 gpm.

The U.S. Geological Survey maintains an observation well network for monitoring ground water levels in upstate New York in cooperation with the New York State Department of Environmental Conservation. The closest, continuously monitored well (Sa 1100) is in Saratoga County at Clifton Park. Figure 6 displays the median (and percentile) water level by month for this well. However, this 180-foot deep well is in a confined aquifer in sand and gravel, and is thus not indicative of the unconfined, sand-based aquifers of the park.

Until recently, the U.S. Geological Survey monitored an observation well in an unconfined, sand-based aquifer in the park (Figure 7). Park staff continue to record monthly depths-to-groundwater readings from this well; data are stored at the park. This well, like the supply wells of the park, is solely recharged by precipitation and its water level fluctuations parallel those of the local hydrograph (see Figure 8).

Knowledge of ground water quality for the park and vicinity is limited. Holmquist (1932) discussed the following results of water quality analyses from water samples (one time samples) for four wells and two springs in the park:

Water Quality Parameter	**Range of Values**
Iron	Not measured
Chloride	0.8 to 18.6 ppm
Nitrate	0.002 to 0.3 ppm
Hardness ($CACO_3$)	11.1 to 235.5 ppm
Alkalinity	16.0 to 293.0 ppm
pH	Not measured

Heath et al. (1963) conducted a limited water quality analysis of selected wells and springs in the park. The quality of water from bedrock varied widely. For example, wells (SA 143, SA 146, SA 1032) in the park showed the following:

Water Quality Parameter	**Range of Values**
Iron	0.15 to 1.8 ppm
Chloride	2.0 to 36 ppm
Nitrate	0.02 to 6.0 ppm
Hardness ($CACO_3$)	34 to 400 ppm
Alkalinity	88 to 378 ppm
pH	7.2 to 8.3

Additionally, hydrogen sulfide gas was one of the most recognizable constituents of water from bedrock wells. Water from SA 1032, for example, contained 20 ppm of sulfide expressed as hydrogen sulfide. Waters above 1 ppm are considered objectionable for most uses.

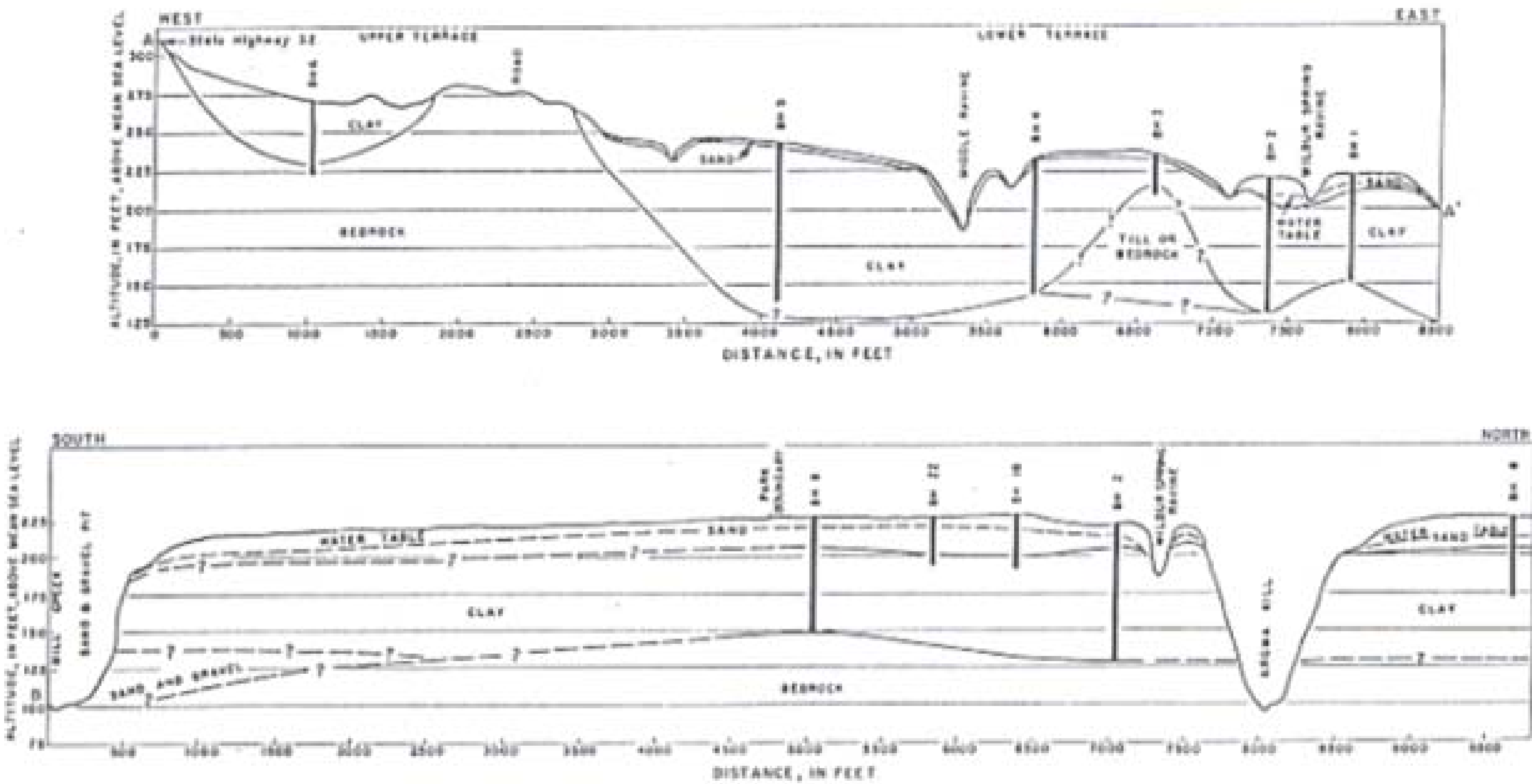

Figure 4. Principal types of unconsolidated deposits in Saratoga National Historic Park (after Heath et al. 1963) based on the geologic sections described in Figure 3.

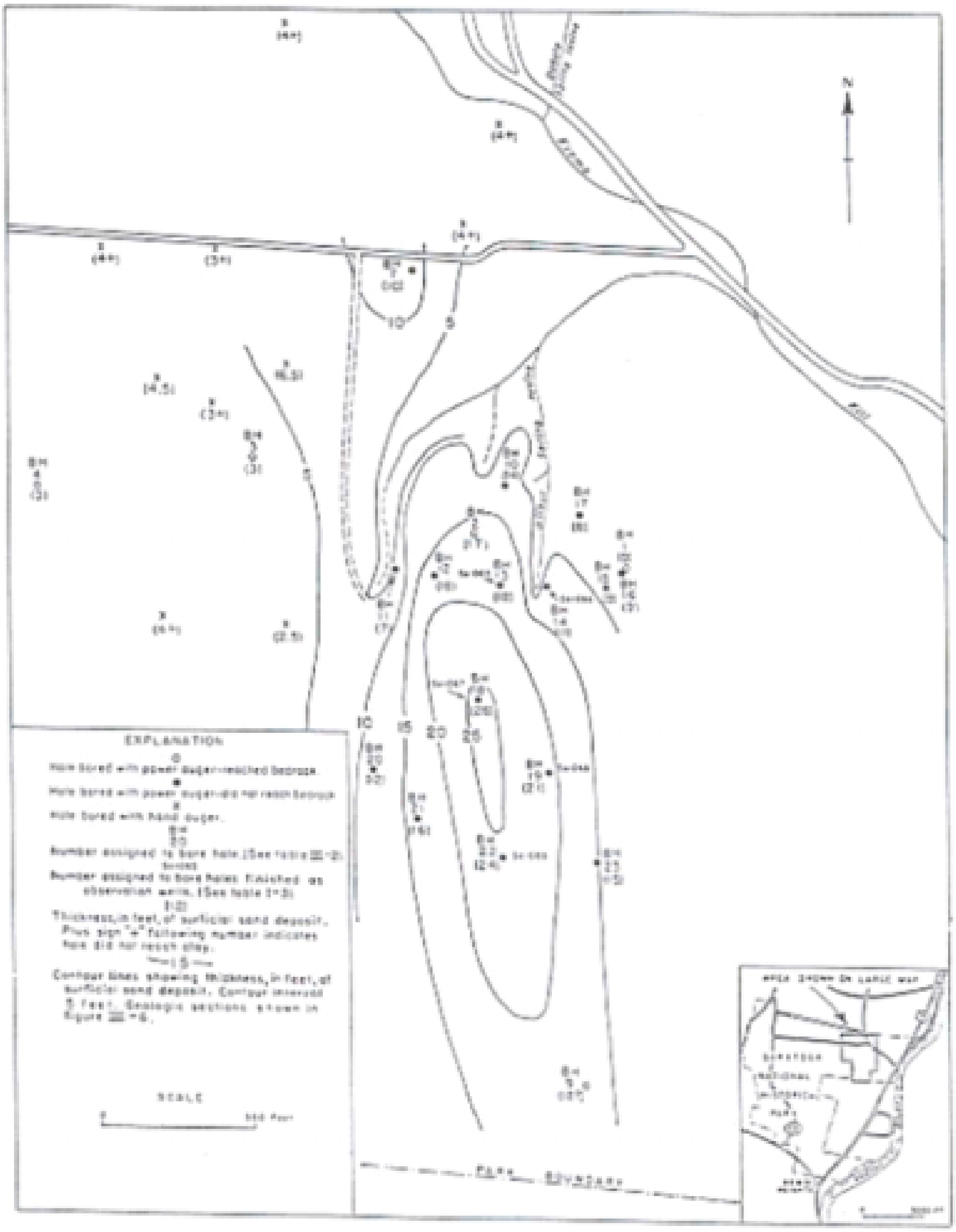

Figure 5. Map showing location of bore holes and observation wells and the thickness of the surficial sand deposit in Saratoga National Historic Park (after Heath et al. 1963).

Two unconsolidated wells in the park (SA 144; SA 145) were not as variable:

Water Quality Parameter	Range of Values
Iron	0.2 ppm
	2 to 5.2_ppm
	0.02 to 0.07 ppm
Chloride	110 to 150 ppm
Nitrate	76 to 217 ppm
pH	7.0 to 7.5

Phillips and Hanchar (1996) and Wall et al. (1998) conducted basinwide assessments as part of the U.S. Geological Survey's National Water Quality Assessment program for the Hudson River basin. These studies provide insight into the potential ground water quality of Saratoga National Historical Park. Phillips and Hanchar, in a retrospective analysis, assessed available nutrient data (limited to nitrate concentrations from 1970 to 1990) from ground water wells the basin. Nitrate is the most soluble and mobile form of nitrogen in ground water. Previous investigations have indicated that all principal aquifers in New York State contain ground water with median nitrate concentrations as N less than the 10-mg/l maximum contaminant level (Rogers 1988). Elevated concentrations may be found, however, in shallow, unconfined systems that are susceptible to contamination from overlying sources of nitrate, such as fertilizers, underground sewage-disposal systems, animal waste, and landfills (Rodgers 1988). Phillips and Hanchar statistically determined a threshold nitrate concentration of 0.3 mg/l for human effects.

Phillips and Hanchar (1996) found that nitrate concentrations in water from unconsolidated deposits ranged from less than 0.1 mg/l to 16 mg/l (median concentration of 0.23 mg/l). Nitrate concentrations in water from bedrock range from less than 0.1 to 11 mg/l (median concentration of 0.3 mg/l). Additional results included:

1) nitrate concentrations in groundwater decreased with depth -- median nitrate concentrations (0.61 mg/l) were higher in unconsolidated aquifers of less than 35 feet compared with concentrations (0.2 mg/l) greater than 35 feet;
2) nitrate concentrations in bedrock aquifers at depths less than 200 feet range from less than
   0.1 to 11 mg/l with a median of 0.26 mg/l, and those at depths greater than 200 feet ranged from less than 0.1 to 3.6 mg/l (median of 0.43 mg/l). Ground water in bedrock aquifers flows along zones of secondary permeability, such as fractures and bedding-plane openings. The high concentrations of nitrate at depth are probably the result of downward flow along fractures that could extend from the land surface and provide a direct conduit for shallow ground-water flow into deep zones;
3) no correlation between nitrate concentration and land use could be made from the available data;
4) no difference between nitrate concentrations in unconsolidated aquifers versus bedrock aquifers; and,
5) median nitrate concentrations for bedrock aquifers beneath developed land was greater than that in ground water beneath undeveloped land -- land use is likely the major controlling factor on nitrate concentrations in bedrock aquifers.

Wall et al. (1998) sampled nitrate from three well networks (agricultural, urban/residential, domestic). Of the 91 total ground water samples, 53 percent had detectable (0.05 mg/l as N) concentrations of nitrate. Only 5 wells had detections above 10 mg/l. None of the wells that exceeded 10 mg/l was used for drinking water.

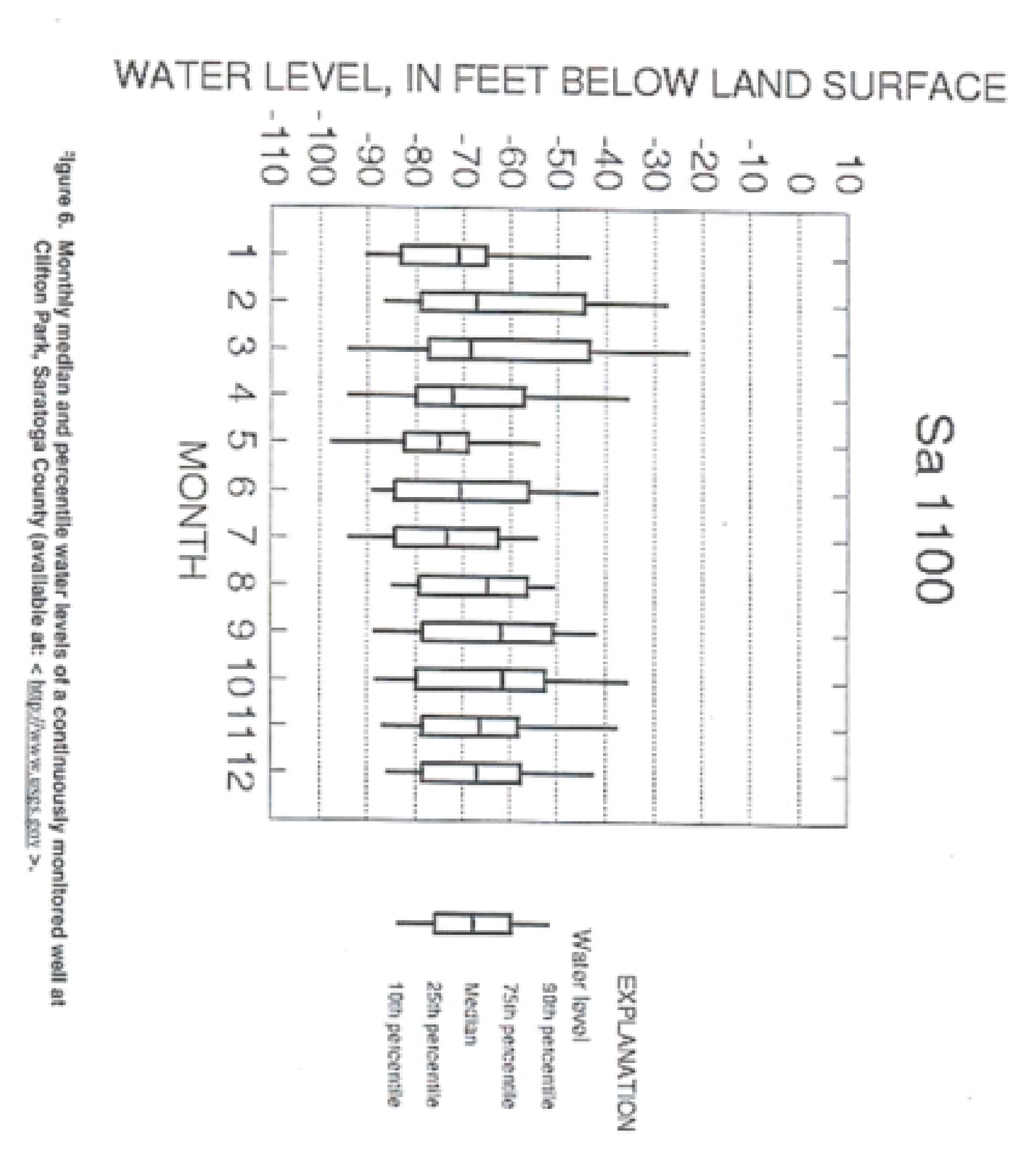

Figure 6. Monthly median and percentile water levels of a continuously monitored well at Clifton Park, Saratoga County (available at: < http://www.usgs.gov >.

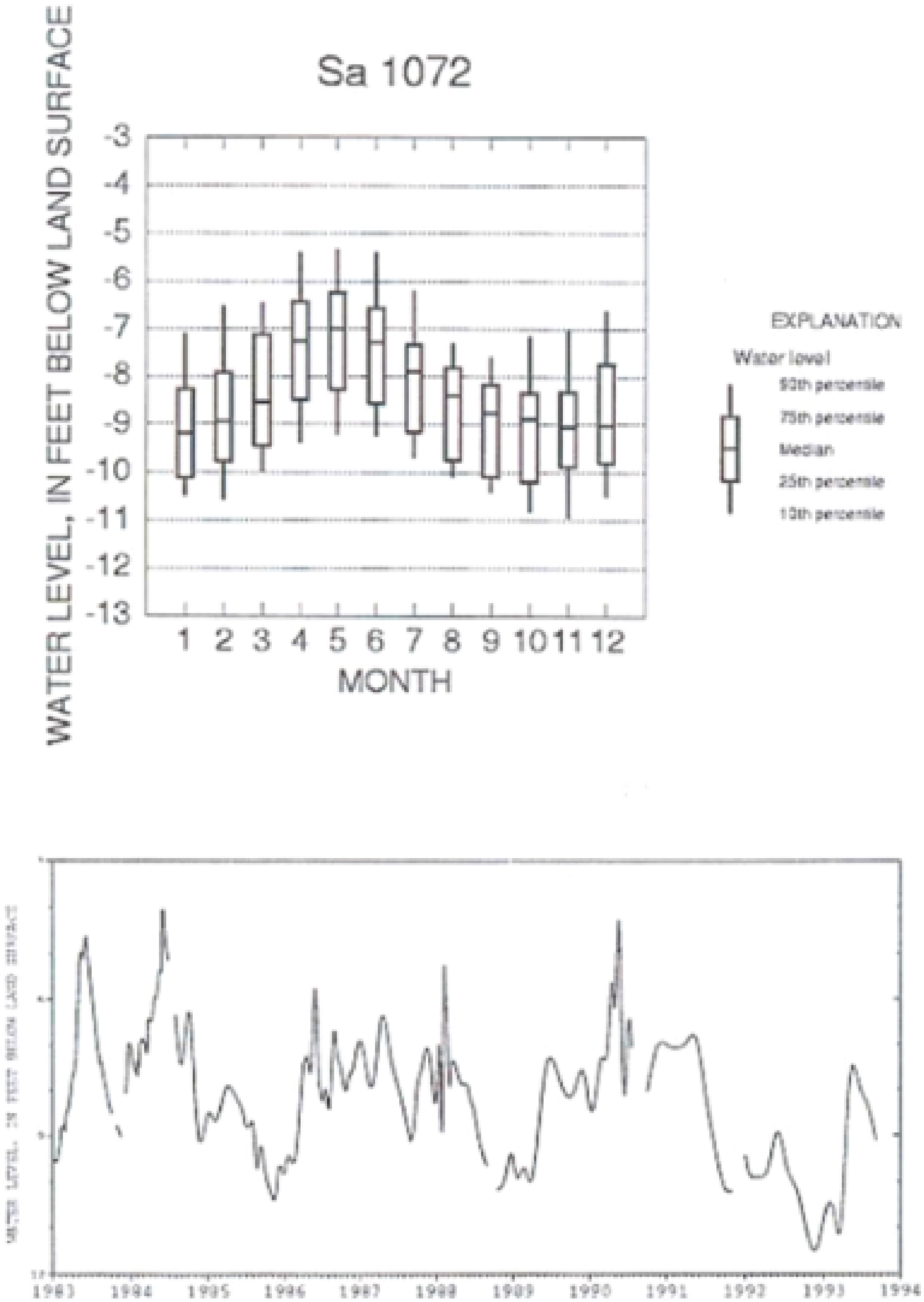

Figure 7. Monthly median and percentile water levels (top) and water level fluctuations (bottom) for the period of record from a now-discontinued monitoring well in Saratoga National Historic Park (available at : < http://www.usgs.gov >.

Additionally, Wall et al. (1998) sampled the same well networks to assess the occurrence of pesticides in ground water. The agricultural wells had the highest number and concentrations of pesticides. Seven pesticides or pesticide-degradation compounds (atrazine, metolachlor, deethylatrazine, diazinon, metribuzin, prometon, and malathion) were detected. Five pesticides (all above except metolachlor and metribuzin) were detected in the domestic wells, but no more than two pesticides was detected in any one domestic well. All concentrations of pesticides in domestic wells were less than 0.3 ug/l with one exception.

SURFACE WATER QUANTITY AND QUALTITY

Other than the Hudson River, no fluvial system within or adjacent to Saratoga National Historic Park is or has ever been monitored for discharge on a consistent basis. However, Heath et al. (1963) measured the flow from two major springs in the park. Decoteau spring averaged approximately 52 gpm over 12 measurements from 1958 to 1959. Wilbur spring (the current potable water supply for the park) averaged approximately 43 gpm for two measurements in 1958.

In an attempt to conduct a seasonal analysis of water quality data collected in and around the park, the National Park Service (1997) found the nearest U.S.Geological Survey Hydro-Climatic Data Network (HCDN) station that is most representative of streamflow conditions at the park. The HCDN is basically a subset of U.S. Geological Survey streamf low stations, including only those stations that are unaffected by artificial diversions, storage, or other disruptions of the natural channel. All HCDN stations generally have at least a 20-year period of record. Consequently, discharge patterns at these stations should reflect only hydrologic and climatic influences. The station most representative of streamflow conditions at Saratoga National Historic Park is the Hudson River at Stillwater, NY (National Park Service 1997; see Figure 1). Figure 8 displays the mean annual hydrograph and distribution of daily flows by month for this Hudson River station. Discharge typically increases from October through December, as temperatures decrease, rainfall increases, and the growing season ends. Discharges for January and February, when temperatures decline and much of the precipitation falls as snow, are typically lower than those for December; and median daily discharge typically peaks in March and April, during spring snowmelt. Discharges generally decline from May through August as snowmelt decreases and temperatures and infiltration increase.
The state classification for Class “C” surface waters (suitable for fish propagation and fishing) is most applicable to the water resources of Saratoga National Historic Park. Although other factors may limit the use of the water for primary and secondary contact recreation, the water quality shall be suitable for both types of recreation. Under this classification, natural conditions such as intermittent flows and streambed conditions may not support fish propagation; however, the waters must be suitable for fish survival.

The state classification for the segment of the Hudson River adjacent to the park is Class “B”. Under this standard the best uses for this water are primary and secondary contact recreation and fishing. The water can also be used for fish propagation and survival.

These classifications define what are the best uses of particular rivers, streams or segments. However, they may not necessarily be strong indicators of water quality. The reason is that the ‘standards’ associated for a “C” river or stream are very similar to those for a “B” river or stream, the only difference usually being that the standards specify that the levels of pollutants cannot hinder the “best uses” for the water.

The National Park Service (1997) conducted surface water quality retrievals for Saratoga National Historic Park from six of the U.S. Environmental Protection Agency’s national databases, including STORET. The results of these retrievals for the study area (limits include 3 miles upstream and 1 mile downstream of park boundary) covered the years 1964 to 1994 and included 69 water quality monitoring stations (FigureS; lable 1), 15 industrial/municipal discharge sites, three municipal water supply intakes, nine water impoundments, and 33 active or inactive U.S. Geological Survey gaging stations. Most (52) of the monitoring stations are outside of park boundaries, and represent primarily either older one-time or intensive single-year efforts by collecting agencies or discontinued stations. The data from these stations are of little use in an assessment of current water quality of the park. However, these data do indicate that surface waters within the study area have been impacted by human activities, including industrial and municipal wastewater discharges and agricultural runoff (National Park Service 1997).

Sixteen water quality monitoring stations represent stations located within park boundaries (Table 1; Figure 9). However, data from all 16 stations represent the park's water quality monitoring program initiated in 1987 but discontinued in 1990 due to funding constraints. This limited water quality monitoring program (Lynch 1987) consisted of 10 parameters measured at 16 stations, primarily over the summer months. Only temperature, specific conductance, dissolved oxygen, pH, and salinity were consistently measured over the 3 years of the program. Nitrate/nitrogen, total phosphate, lead, PCBs, and fecal coliform were limited to 1987 and, with the exception of fecal coliform, were one-time samples only.

Although limited, the results of this program do point out potential water quality problems that existed and could exist today. For example, PCBs were present only in trace amounts and fecal coliform often exceeded the EPA standard during the summer months of 1987 on Kroma Kill, Mill Creek, American Creek, and Devil's Hollow.

In 1991, the U.S. Geological Survey began to implement a full-scale National Water-Quality Assessment (NAWQA) program. The goals of this program are to describe the status of and trends in quality of a large, representative part of the Nation's surface and ground water resources, and to identify the major natural and human factors that affect the quality of these resources. In addressing these goals, the program should produce a wealth of water quality information that will be useful to managers at national, state, and local levels. The Hudson River basin was among the first 20 NAWQA study units selected. Because of the complexity and extensiveness of the Hudson River basin study, results are just now being published in various formats.

As part of the Hudson River basin NAWQA program, Phillips and Hanchar (1996) retrospectively analyzed available nutrient, pesticide, volatile organic compound, and suspended-sediment surface water data collected throughout the Hudson River basin by the U.S. Geological Survey from 1970 to 1990. Of particular interest to the park for a comparison with its drainages is their analysis of Esopus Creek at Shandaken, NY, a small, forested (defined as more than 78 percent forest cover and less than 18 percent agricultural and urban land combined), headwater watershed (approximately 60 mi^2 drainage area). In general, nitrate and total nitrogen concentrations increased with increasing discharge, showing little seasonal variability. In contrast, total phosphorus concentration showed little significant change with discharge as concentrations were near the detection limit.

Plots of nutrient concentration in relation to discharge at sites representing different land uses can help identify whether nutrients are derived from point or nonpoint sources. If nutrient concentrations increase with increasing discharge, nonpoint sources are probably the main control, but if the concentrations decrease with increasing discharge, point sources are probably the main control. The above results indicate that nitrogen in streams that drain small, forested watersheds of the Hudson River basin is derived mainly from nonpoint sources.

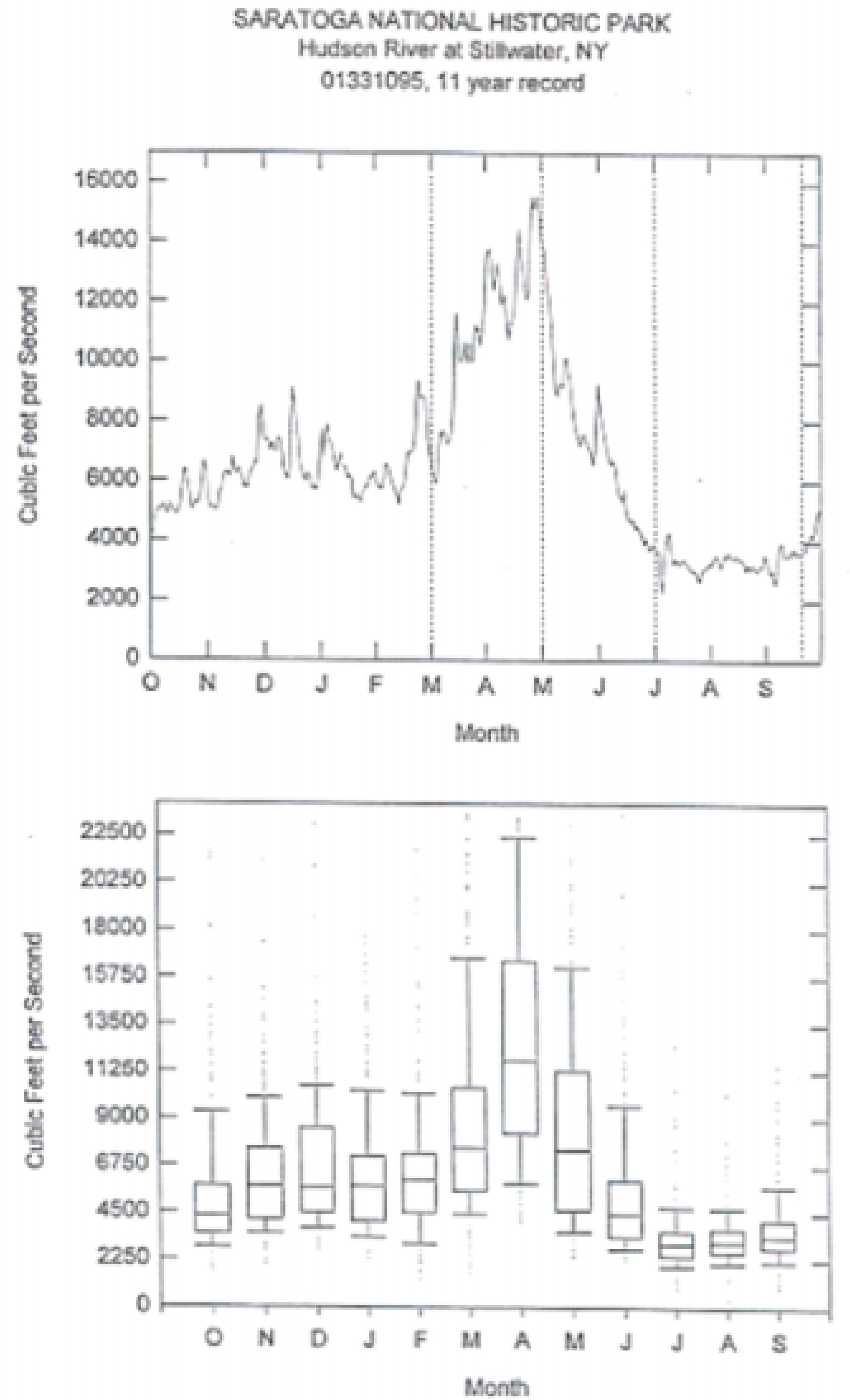

Figure 8. Mean annual hydrograph (top) and distribution of daily flows by month (bottom) for the Hudson River at Stillwater, NY (from National Park Service 1997).

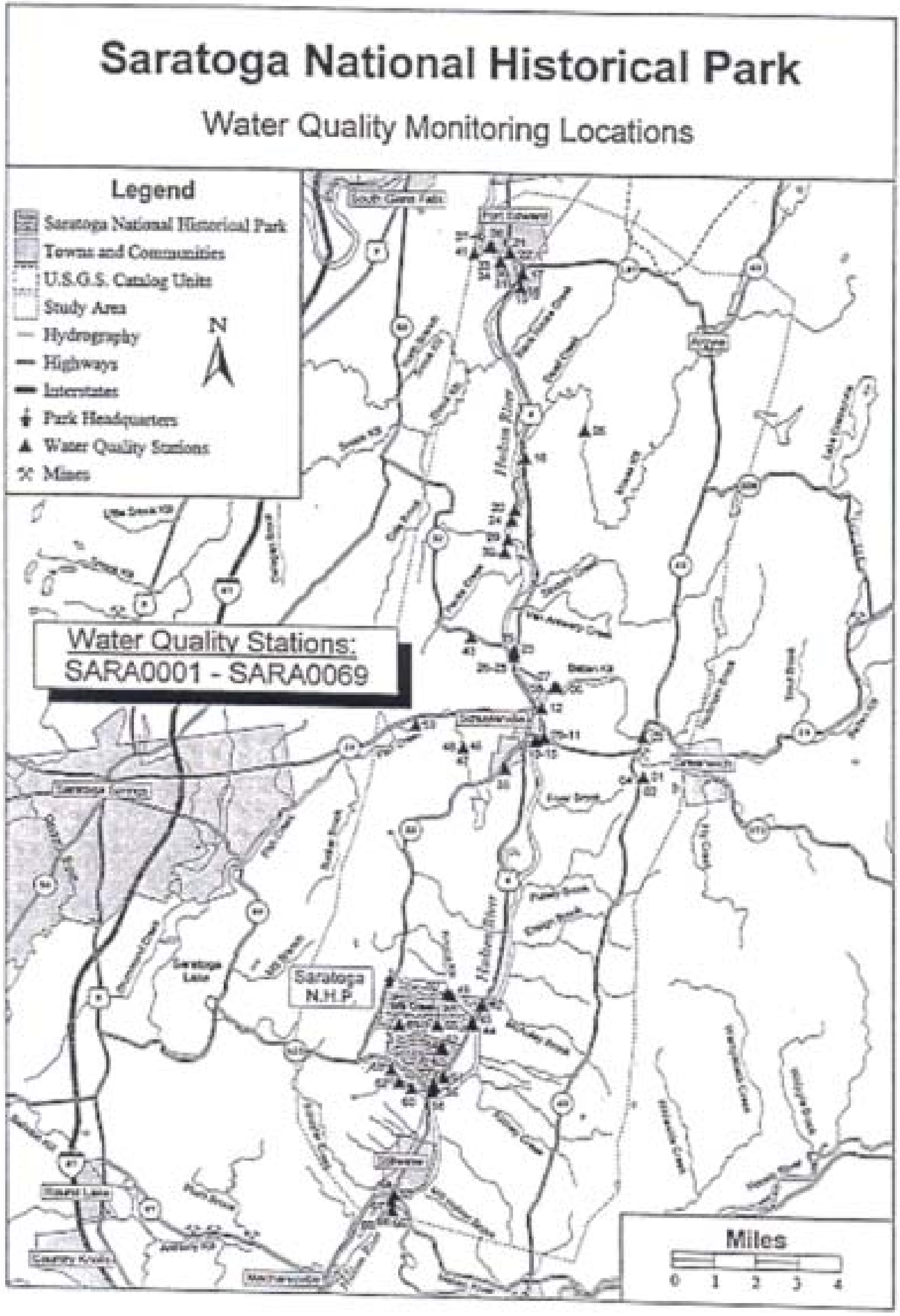

Figure 9. Location of past and current water quality monitoring stations in Saratoga National Historic Park and vicinity (from National Park Service 1997).

Table 1. Water quality monitoring stations located in a study area with limits ot 3 miles upstream and 1 mile downstream of the boundaries of Saratoga National Park (after National Park Service 1997; see Figure 9). Stations marked by an '*' are monitoring stations located within the boundaries of the park -- period of record is for 1987 to 1990 for these stations.

Station ID#	Location Description	Total No. of Observations
SARA0001	Batten Kill in Middle Falls © Nimo Forebay	4068
SARA0002	Batten Kill at Route 29 in Middle Falls	645
SARA0003	Batten Kill at Middle Falls	2115
SARA0004	Batten Kill Creek	3454
SARA0005	Moses Kill near Fort Miller, NY	24
SARA0006	Batten Kill at Clarks Mill	34
SARA0006	Batten Kill at Clark's Mill	
SARA0007	batten Kill at Clark's Mill Schuylerville	2
SARA0008	Batten Kill in Greenwich © Clark Mill Dam	0
SARA0009	Hudson River at Schuylerville	4851
SARA0010	Hudson River at Schuylerville at route 29 Bridge	1163
SARA0011	Hudson River at Schuylerville at route 29	0
SARAOO12	Batten Kill	0
SARAOO13	Fish Cr. At mouth at Schuylerville	795
SARAOOt4	Fish Cr. in Schuylerville @ Schuylerville STP (Bank)	0
SARA15	Fish Creek	181
SARAOO16	Hudson River 5 miles below Fort Edward	190
SARAOO17	Hudson River at For Edward below GE	64
SARAOO18	Lake Champlain-Champlain Canal	15
SARAOO19	Lake Champlain-Champlain Canal	0
SARAOO2O	U. Hudson A. in Northumberland above Thompson	0
SARAOO21	U. Hudson R. in Ft. Edward 0 village dock	1619
SARAOO22	Hudson River	1520
SARAOO23	Hudson River © Route 4 bridge in thompson	534
SARAOO24	Hudson River at Thompson Island	181
SARA0O25	U. Hudson R. in Thompson at Route 4 Bridge	2783
SARA0026	Thompson	13
SAHAOO27	Hudson River	2307
SARAOO28	Hudson River at Thompson NY	1069
SARAOO29	Hudson River near Ft. Miller, NY	555

SARAOO3O	U. Hudson A. in Ft. Edward © At. 197 Bridge (W. Channel)	1894
SARAOO31	Hudson River at Rogers Island at Ft. Edward	7278
SARAOO32	Tuttle Brook near Schuylerville	24
SARAOO33	Hudson River in Ft. Edward at Route 197	0
SARAOO34	Hudson River	1294
SARAOO35	Fish Creek at Victory Mills, NY	2
SARAOO36	U. Hudson A. in Ft. Eward © Paper mill intake	48
SARAOO37	Hudson River at Fort Edward, NY	4547
SARAOO38	Hudson River	2943
SARAOO39	U. Hudson River in Ft. Edward 0 Nimo WTP intake	2737
SARAOO4O	Hudson River	56
SARAOO41	Hudson River at Fort Edward	38
SARAOO42*	Champlain Canal and Duck Pond	3
SARAOO43	Hudson River at Ft. Miller	176
SARAOO44*	Kroma Kill and Route 4 Culvert	1
SARAOO45*	Lower Kroma Kill along Route 4	160
SARAOO46	Fish Creek near Grangerville, NY	1032
SARAOO47	Fish Creek in Saratoga © Brgyne. Rd. Bridge	1123
SARAOO48	Fish Creek in Saratoga at Burgoyne Rd.	0
SARAOO49*	Upper Kroma Kill at Culvert	189
SARAOO5O*	Tributary to Upper Kroma Kill	165
SARAOO51 ·	Vyle Pond River Backwater Area	1
SARAOO52*	Lower Mill Creek	160
SAR.A0053*	Lower Mill Creek/Robbie's Ditch	1032
SARA0054'	Robbie's Ditch	167
SARAOO55*	Mill Creek behind Stop 8	173
SAAAOO56*	American's Creek — Route 4 Culvert	1
SARAOO57*	Americans Creek at Route 4	173
SARAOO58'	Vyle Pond Route 4	2
SARAOO59	Saratoga Lake	31
SARAOO6O*	Lower Devil's Hollow	132
SARAOO61 ·	Mill Creek near Murphy Monument	162
SARAOO62*	Upper Devil's Hollow	108
SARAOO63	U. Hudson R. in Stillwater © At. 67 Br.	3821
SARAOO64	Hudson River	3823
SARAOO65*	Culvert on Bill Smith Road	114

SAAAOO66	Hoosic River near Stillwater, NY	665
SARAOO67	Hoosic River at Stillwater, NY	8816
SARAOO68	Hoosic A. in Schaghticoke © Lock 4	1120
SARAOO69	Hoosic River	1058

Kroma Kill

Phillips and Hanchar (1996) found that median concentrations of all nutrients (except dissolved ammonium) for the agriculturally- and urban-watershed sites greatly exceed those medians for the forested watershed sites. Correlations between median dissolved nitrate, total nitrogen, and total phosphorus concentrations and site characteristics (including predominant land use and population density in the watershed) indicate that the characteristic with which all nutrients are most closely related is population density.

Nitrogen and phosphorus yields (mass per unit area) from watersheds were calculated and related to the rates of inputs to illustrate the major patterns of nutrient movements through the Hudson River basin. The relations among average annual yield and watershed characteristics indicate that nutrient yield is a function of agricultural land use and population density. Average annual yields of dissolved nitrate, total nitrogen, and total phosphorus generally increase with increasing percent agricultural area and increasing population density.

Nutrients, organic compounds (including pesticides), and metals can sorb to suspended sediment and therefore, can affect the transport of a wide variety of constituents. Suspended-sediment concentrations and yields in the Hudson River basin are related to land use.

Sediment concentration generally increases with discharge. Sediment concentrations at the Hudson River at Stiliwater site are usually less than 10 mg/l when discharge is less than 10,000 cfs but generally increase at an increasing rate to 50 mg/l at discharges of more than 35,000 cfs. The lowest median suspended-sediment concentrations in the Hudson River drainage are at sites representing forested watersheds. Median suspended-sediment concentrations for sites in the upper Hudson River basin range from 4 to 7.5 mg/l. Forest cover at these sites ranges from more than 90 percent of the drainage area upstream from Glen Falls, NY to less than 80 percent of the drainage area upstream from Waterford, NY. These results indicate that suspended-sediment concentrations in the Hudson River basin are inversely proportional to percent forest cover. The effect of urbanization on suspended-sediment concentration could not be assessed because data are unavailable from sites in urban watersheds.

Sediment transport in the Hudson River basin is highly variable over time and space. For example, in an average year, about half of the total annual sediment load at Waterford, NY is transported in the 18 days with the highest discharges.

Sediment yield is related to watershed land use and drainage area. The relationship between sediment yield and land use is similar to that for sediment concentration and land use. Watershed land use in the Upper Hudson subbasin has a greater effect than drainage area on sediment yield. For example, the drainage area of the Hudson river from Glen Falls to Green Island increases nearly threefold (2,800 square miles to 8,000 square miles), and the sediment yield increases over fourfold, from 0.053 (tons/d)/square mile to 0.22. This can probably be attributed to the decrease in the proportion of forest cover from the watershed above Glen Falls to the watershed above Green Island.

Phillips and Hanchar (1996) determined that suspended sediment and pesticide data were insufficient for a basinwide assessment. However, it appears from the limited data that both are related to land-use characteristics. For example, DDT was universally applied to agricultural, urban, and forested watersheds from 1940 to the early 1970s -- total DOT was detected in all but one of 21 sites with available data. In contrast, chlordane was applied primarily in urban areas over essentially the same time period. It was detected at over 80 percent of the urban sites and at less than 20 percent of the non-urban sites.

Wall et al. (1998) summarized the major issues and findings in the Hudson River basin based on NAWQA program sampling over the years 1992 to 1995. Stream-bottom sediments were collected at 44 sites on 35 streams and rivers across the Hudson River Basin from 1992 to 1994 for analysis of trace elements and organic contaminants. Seven selected heavy metals (Table 2) that have been shown to adversely affect the quality of stream-bottom sediments, and thus pose a risk to the surrounding aquatic ecosystem, were discussed. The New York State Department of Environmental Conservation has proposed concentration screening criteria for metals in stream-bottom sediments to indicate the concentrations that could affect aquatic organisms (New York Department of Environmental Conservation 1994) (Table 2).

In general, metal concentrations in stream-bottom sediments were positively correlated with urban land use (Wall et al. 1998). Proposed metals criteria were exceeded most frequently at sites in urban and large mixed-land-use watersheds. The proposed Severe Effect Level (Table 2) was exceeded only in urban and large watersheds. Sediment from every urban site exceeded the Lowest Effect Level (Table 2) for five of the seven metals.

Some of the highest chromium concentrations were along the mainstem of the Hudson River. Concentrations were highest at Stillwater (160 ug/g) and decreased downstream to 130 ug/g at Waterford (Wall et al. 1998). The lowest chromium concentrations were at sites upstream from Stillwater, at Luzerne (28 ug/g) and Hadley (47 ug/g), where the Hudson River drains mainly forested land. This distribution pattern is similar to that observed previously for heavy metal concentrations in upper Hudson River sediments and is consistent with a known point source of heavy metals between Hadley and Stillwater (Wall et al. 1998).

Samples of stream-bottom sediments from 33 sites across the Hudson River Basin were analyzed for 79 semivolatile organic compounds (Wall et al. 1998). Of the 79 analyzed, 27

Table 2. Screening criteria proposed by New York State Department of Environmental Conservation (NYSDEC) for metals in stream-bottom sediment (after Wall et al. 1998). Effect levels are in micrograms per gram.

Metal	Effect Level*	
	Lowest	Severe
Cadmium	0.6	9.0
Chromium	26	110
Copper	16	110
Lead	31	110
Mercury	0.15	1.3
Nickel	16	50
Zinc	120	270

*Effect levels used by NYSDEC represent two risk levels for metals contamination in sediments. Sediment is considered contaminated if either criterion is exceeded. The sediment is considered moderately affected if only the lowest effect level is exceeded and severely affected if both levels are exceeded.

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included organic compounds known as polycyclic aromatic hydrocarbons (PAHs). PAHS are formed mainly as byproducts of combustion, such as fossil fuel power generation, numerous industrial processes, and forest fires (Neff 1979). Generally speaking the percentage of urban and industrial land use in the watershed upstream from each site is linked with PAH concentrations (based on a ranking). The Hudson River at Stiliwater ranked 30 out of the 33 sites (higher rank corresponds to lower concentrations) — upstream of this site there is only approximately 2.2 percent of urban and industrial land use.

A synoptic survey for pesticides in streams and rivers in the basin was conducted in 1994 at 46 sites on 41 streams and rivers (Wall et al. 1998). Eighty-five percent had detectable concentrations of at least one pesticide; nine percent had detectable concentrations of more than five pesticides. Among the 46 sites sampled, 15 pesticides were detected: 8 herbicides, 2 herbicide-degradation compounds, and 5 insecticides. The highest concentrations of 12 of the 15 pesticides were in streams and rivers draining either agricultural or urban land. The most frequently detected herbicides were atrazine and metolachlor and the most often detected insecticides were diazinon and carbaryl. Most of the concentrations detected in the synoptic survey were low concentrations, ranging from 0.002 to 0.05 ug/l, and no concentration exceeded any available maximum concentration limit or health advisory.

Wall et al. (1998) showed that, of the stream samples, 93 percent contained detectable concentrations of nitrate, but the highest concentration was only 1.4 mg/l, and the median concentration for all the streams was 0.35 mg/l.

ACIDIC DEPOSITION (ACID RAIN)

The main components of acidic deposition are sulfuric and nitric acids that are derived primarily from sulfur dioxide and nitrogen oxide gases created during fossil-fuel combustion. Stoddard (1991) and Murdoch and Stoddard (1993) reported that soil and surface water in the State of New York have been affected by long-term exposure to acidic deposition. The most important effects of acidic deposition on soils are the mobilization of aluminum due to increased soil acidity and the leaching of base cations from soil-exchange sites (Ruess and Johnson 1986). As base cations become depleted, the alkalinity of streams and lakes decreases, and the surface water becomes more susceptible to episodic acidification during snowmelt and storms (Stoddard 1991).

Clow and Mast (1999) summarized trends in precipitation and stream water chemistry from 1984 to 1996 at eight precipitation monitoring sites (one in New York State) and five nearby streams (one in New York State) operated by the U.S. Geological Survey in the northeastern US. For these sites sulfate concentrations decreased during the 13 year monitoring period. The magnitudes of decreases in precipitation sulfate were similar to the magnitudes in stream sulfate concentrations, suggesting that changes in precipitation chemistry could account for the changes in stream water chemistry.

Concentrations of calcium+magnesium decreased at seven of eight precipitation monitoring sites and in three of five streams during the monitoring period. The decreases in calcium+magnesium concentrations probably reflect decreased inputs of particulates to the atmosphere. The decreases in stream water calcium+magnesium concentrations probably are due to a combination of decreased calcium+magnesium deposition and decreased leaching of calcium and magnesium from the soil. Decreased leaching of calcium and magnesium could be related to lower acidic deposition rates or because calcium and magnesium have been depleted from the soils.

Precipitation acidity and stream alkalinity showed no trends over the monitoring period at the New York sites. The magnitude of the decreases in precipitation acidity generally were similar to magnitudes of the trends in precipitation sulfate, indicating that recent decreases in sulfate deposition are now being reflected in decreased precipitation acidity. Changes in stream water alkalinity reflect a balance between decreases in stream water sulfate and calcium+magnesium. In streams where sulfate and calcium+magnesium decreased, alkalinity showed no trend; however, where sulfate decreased and calcium+magnesium was stable, alkalinity increased at one of two sites. The balance between sulfate, calcium÷magnesium, and alkalinity is due to the neutralizing effect of chemical reactions in soil that involves calcium and magnesium, such as cation exchange and mineral weathering. Those reactions generally neutralize acidity or generate alkalinity, which then may be transported to aquatic ecosystems by flowing soil water

Clow and Mast (1999) conclude that although decreases in sulfur dioxide emissions are now apparently being reflected in decreased precipitation and stream water sulfate concentrations, the decreases have not yet resulted in widespread increases in stream water alkalinity. Increases in alkalinity will be minimal until the rate of acidic deposition is reduced substantially less than the rate of cation re-supply by weathering and atmospheric deposition.

Hudson River PCBs

Over the past 30 years, numerous studies have documented elevated levels of PCBs in the Hudson River (State of New York et al. 1997; Wall et al. 1998). As a result, a 200-mile section of the river from Hudson Falls to the Battery in New York City was designated a Superfund site in 1983 by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency 1984; 1991). This area is recognized as one of the most highly PCB-contaminated ecosystems in North America (Rivlin 1998). The U.S. Environmental Protection Agency determined that the primary contributors of PCBs to the Hudson River are two, General Electric-owned, capacitor manufacturing plants located at Hudson Falls and Fort Edward, NY (Figure 1). Saratoga NHP is downstream from these plants approximately 10 (Schuylerville Unit) to 20 (Battlefield Unit) river miles (Figure 10).

In December 2000 the U.S. Environmental Protection Agency released its proposed plan for the Hudson River Superfund site (http://www.epa.gov/rO2eartWsuverfnd/hudson/oroposedplan.pdf).

This draft plan calls for targeted dredging of PCB-contaminated sediments. The U.S. Environmental Protection Agency is scheduled to sign the Record of Decision in June 2001.

WETLANDS, FLOODPLAINS AND RIPARIAN AREAS

The Hudson River floodplain and wet meadows are host to many park wetlands. As such, the sedge family is the most numerous plant family found in the park (Stalter et al. 1993). Four species from this family located on the battlefield appear in the "New York Rare Plant Status List" for 1996. Two are defined as being critically imperiled in New York State *(Carex davis!!; C. polystachyos* var. *texensis)),* the other two are on the Watch List *(Cyperus erythrorhizos* and *Carex bush!!)* (Howard 1996). Watch List species are defined as being sufficiently uncommon such that their condition should be monitored.

The U.S. Fish and Wildlife Service in conjunction with the National Wetlands Inventory has completed a wetland inventory for the park (Tiner et al. 2000). Most wetland plant species have been identified and a wetland map has been developed. Based on these maps, the park is dominated by palustrine wetlands (Figure 11). This classification, from the system developed by Cowardin et al. (1979), includes all nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation and emergent mosses or lichens. This classification was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie. It also includes the small, shallow, permanent or intermittent water bodies often called ponds.

Palustrine wetlands may be situated shoreward of lakes, river channels; on river floodplains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except during severe floods.

A total of 175.9 acres of palustrine wetlands were inventoried in the park (about six percent of the park). Forested wetlands were the predominant type, occupying 120 acres and representing 68 percent of the park's wetlands. Palustrine emergent wetlands (marshes and wet meadows) totaled 24 acres that accounted for 14 percent of the park's wetlands, while 14 acres or 8 percent of the park's wetlands were mixed stands of forested and scrub-shrub wetlands. The remaining wetlands were 6.6 acres of palustrine scrub-shrub, 6.1 acres of ponds, and 4.8 acres of mixed emergent/shrub wetlands, and 0.5 acres of farmed wetland.

Significantly modified wetlands in the park include the following: 84.1 acres of impounded wetlands, 9.3 acres of partly drained wetlands, and 0.2 acres of excavated wetlands. Their total represents 53 percent of the park's wetland acreage and at least some of these wetlands may be candidates for some type of restoration.

Linear wetlands (narrow wetlands too small to map as polygons) were represented by the following: 38.5 miles of palustrine emergent wetland, 0.1 mile of farmed wetland, 81.9 miles of forested wetland, 0.3 miles of mixed shrub/emergent wetland, 37.5 miles of scrub-shrub wetland, 11.2 miles of unconsolidated bottom (narrow ponds and wide ditches), and 41.5 miles of intermittent streambed. In addition, there are 94.2 miles of perennial streams.

Wetlands were also classified by hydrogeomorphic properties. This classification allowed individual wetlands to be identified. For Saratoga National Historical Park a total of 49 individual wetlands were mapped, excluding linear wetlands. Fifty-nine percent of these wetlands were lotic wetlands associated with rivers and streams, while the remainder (41 percent) were terrene wetlands (isolated or headwater outflow wetlands). Fifteen wetlands were significantly impacted by human actions (diked, excavated, or partly drained); therefore, these actions have affected about a third of the park's wetlands and about half of the acreage.

Figure 10. Location of the Thompson Island Pool (TIP). Black squares represent park units; Schuylerville unit is northern square and the Battlefield unit is the southern square (modified from > http://www.epa.gov/hudson/map-pix.htm >).

River Road Wetland

From an acreage standpoint about 79 percent of the park's wetland acreage occurred along rivers and streams. Half of the acreage (51 percent) consisted of floodplain wetlands along the Hudson River, while 21 percent occurred as stream basin (depressional) wetlands along streams. Under natural conditions, both of these types are likely to be significant for temporary storage of floodwaters and are important for reducing the risk of flood damage downstream. Many of them have been diked, thereby restricting flood storage to water that enters through existing culverts during high flows in the Hudson River.

Only 12 acres of stream wetlands were found on sloping terrain. Most of these slope wetlands were designated as headwater wetlands. They are likely to be ground water discharge sites important for stream flow maintenance.

Terrene wetlands are either headwater wetlands or isolated wetlands surrounded by upland. About 12 acres were headwater wetlands serving as sources of various streams and therefore important for stream flow maintenance and for maintaining fish habitat downstream. Isolated wetlands account for 15 percent (26 acres) of the park's wetland acreage. Some of these may be connected to other wetlands through seasonal overflows and intermittently flowing drainage ways in late winter and early spring, yet they remain relatively isolated for much of the year. Some isolated wetlands may possess vernal pools that are essential breeding grounds for certain amphibians like salamanders, wood frogs, and spring peepers.

A comprehensive botanical survey of the wetlands was not in the scope of work for this mapping project, but a list of plants observed in the park's wetlands by Tiner et al. (2000) follows:

Trees

American Elm *(Ulmus americana)*
Black Willow *(Salix nigra)*
Gray Birch *(Betula populifolia)*
Green Ash *(Fraxinus pennsylvanica)*
Quaking Aspen *(Populus tremuloid9s)*
Silver Maple *(Acer saccharinum)*

Figure 11. Classification and distribution of wetlands in Saratoga National Historical Park. See Cowardin et al. (1979) for an explanation of wetland types.

Swamp White Oak (*Quercus bicolor)*

<u>Shrubs</u>

Broad-leaved Meadowsweet *(Spiraea latifolia)*
Buttonbush *(cephalanthus occidentalls)*
Common Buckthom *(Rhamnus cathartica)*
Maleberry *(Lyon/a ilgustrina)*
Nannyberry *(viburnum lentago)*
Northem Arrowwood *(Viburnum recognitum)*
Red Osier *(Cornus stolonifera)*
Red-panicled Dogwood *(Comus foemina)*
Silky Dogwood *(Cornus amomum)*
Smooth Winterberry *(hex !aevigata)*
Speckled Alder *(Alnus rugosa)*
Steeplebush *(Spiraea tomentosa)*

<u>Woody vines</u>

Grape *(Vitis* sp.)
Japanese Honeysuckle *(Lonicera japonica)*
Swamp Dewberry *(Rubus hispidus)*

<u>Apuatics</u>
Duckweeds *(Lemna* spp.)

<u>Ferns</u>

Marsh Fern *(Thelypteris thelypteroides)*
Royal Fern *(Osmunda regahis)*
Sensitive Fern *(Onochea sensibihis)*

<u>Grasses</u>

Bluejoint Grass *(Calamagrostis canadensis)*
Lowland Broomsedge *(Andropogon glomeratus)*
Manna Grass *(Glyceria striata)*
Panic Grass *(Panicum* sp.)
Reed Canary Grass *(Phaharis arundinacea)*
Rice Cutgrass *(Leers/a oiyzoides)*
Spreading Bent-grass *(Agrostis stolonifera)*
Timothy *(Phheum pratense)*
Wild Millet *(Echinochloa crus-gahhi)*

<u>Buirushes</u>

Green Bulrush *(Scirpus atrovirens)*
Wool-grass *(Scirpus cyperinus)*

<u>Other Sedaes</u>

Bearded Sedge *(Carexcomosa)*
Bladder Sedge *(Carex intumescens)*
Broom Sedge *(Carex scoparia)*
Fringed Sedge *(Carex cnn/ta)*
Fox Sedge *(Carex vulpinoidea)*
Hop Sedge *(Carex lupuhina)*
Lurid Sedge *(Carexhunida)*
Spike-rushes *(Eleocharis* spp.)
Three-way Sedge *(Duhichium arundinaceum)*

<u>Rushes</u>

Soft Rush *(Juncus eftusus)*

<u>Other Grasslike Plants</u>

Broad-leaved Cattail *(Typha latifohia)*
Bur-reed *(Sparganium americanum)*

water 1-lorsetail *(equiserum riuviarile)*

Flowering Herbs

Arrow-leaved Tearthumb *(Polygonum sagittatum)*
Bedstraw *(Ga/kim* sp.)
Blue Flag *(Iris versicolor)*
Blue Vervain *(Verbena hastata)*
Boneset *(Eupatorium perfoliatum)*
Bugleweed *(Lycopus virginicus)*
Buttercup *(Ranunculus* sp.)
Clearweed *(Pilea pumila)*
Devil's Beggar-ticks *(Bk/ens frondosa)*
False nettle *(Boehmeria cylindrica)*
Grass-leaved Goldenrod *(Euthamia graminifolia)*
Joe-Pye-weed *(Eupatoriadeiphus* sp.)
Ladies'-tresses *(Spiranthes* sp.)
New England Aster *(Aster novae-angliae)*
Nodding Beggar-ticks *(Bidens cemua)*
Pinkweed *(Polygonum pennsylvanicum)*
Purple Loosetrife *(Lythrum sailcaria)*
Rough-stemmed Goldenrod *(Solidago rugosa)*
Skullcap *(Scutellaria* sp.)
Swamp Aster *(Aster puniceus)*
Swamp Beggar-ticks *(Bidens connata)*
Swamp Candles *(Lysimachia terrestris)*
Tall Goldenrod *(Solidago altissima)*
Turtlehead *(Chelone glabra)*
Water Peppers *(Polygonum hydropiperoides* and *P. hydropiper)*
Water Purslane *(Ludwigia palustris)*

Natural riparian zones are some of the most diverse, dynamic, and Complex biological/physical habitats on the terrestrial portion of the planet (Naiman et al. 1993). The riparian zone encompasses that stream channel between low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997).

Physical functions of riparian zones include: 1) sediment transport and channel morphology; 2) sources of woody debris which dissipates energy, traps moving materials, and forms habitat for fish and macroinvertebrates; 3) microclimate control; and 4) key landscape components that maintain biological connections along extended and dynamic environmental (Naiman and Decamps 1997). Ecologically, riparian zones function as: 1) sources of nourishment through both external inputs to the aquatic system and food for terrestrial herbivores; 2) filters of overland runoff, thereby controlling nonpoint sources of pollution (sediment and nutrients); and 3) refuges for adjacent areas and, in some cases, as corridors for migration and dispersal.

AQUATIC BIOLOGY AND ECOLOGY

Mitchell (1814) provided the first major study of New York fish fauna. However, comprehensive surveys of the fishes of state were not completed until the 1 930s, when the New York State Conservation Department began its biological survey of all of the state watersheds. Greely and Bishop (1933) included a checklist of fishes found in the upper Hudson River, as well as a checklist of fishes found in subdivisions of the watershed.The park has compiled a list of 12 fish species (unpublished data) that occur in the park. No distribution or abundance data have been compiled. The species are as follows:

Semotilus atromaculatus (creek chub)
Crassius auratus (goldfish)
Catostomus commersoni (white sucker)
Alosa pseudoharangus (alewife)

Salmo trutta (brown trout)
Ameiurus natalls (yellow bullhead)
Etheostoma nigrum (Johnny darter)
Fundulus diaphanus (banded killifish)
Lepomis gibbosus (pumpkinseed)
L. macrochirus (bluegill)
Micropterus salmoides (largemouth bass)
Perca flavescens (yellow perch)

A fish inventory has not been completed although the University of Massachusetts Cooperative Fishery Unit has been funded to conduct a multi-park inventory of fish species. This study will include Saratoga National Historical Park, and will provide the park with information on fish species composition and relative abundance as well as the distribution of habitat types. Some fishing occurs in the park; limits, sizes, and seasons are regulated by the New York Department of Environment Conservation.

Hynd and Bain (1996) attempted to describe the fisheries and habitat conditions of the Hudson River in the vicinity of Corinth, NY prior to impoundment for waterpower development (circa 1880). Fish distribution information in early ichthyological works for this area is limited and anecdotal, making it nearly impossible to pinpoint a species to a specific watershed, let alone a specific reach of a river. Hynd and Bain instead reconstructed the likely fish fauna using recent information on water temperatures, river gradient, stream size, observed channel habitat structure, fish species lists, and species habitat requirements. The inferred, species-poor fish fauna was found typical of formerly glaciated Atlantic coast rivers in northeastern US. This fish fauna included 15 species that were native and common in the Hudson River near Corinth:

Alosa sapidissima (American shad)
C.commersoni (white sucker)
Notropis. atherinoides (emerald shiner)
N. cornutus (common shiner)
N. hudsonius (spottail shiner)
N.rubellus (rosyface shiner)
Rhinicthys cataractae (longnose dace)
Semotilus atromaculatus (creek chub)
S. corporalis (fallfish)
Noturus flavus (stonecat)
Anguilla rostrata (American eel)
Percopsis omiscomaycus (trout-perch)
Perca flavescens (yellow perch)
Percina caprodes (log perch)
L. auritus (redbreast sunfish).

Almost all sport species such as brown trout *(Salmo trutta),* bluegill *(L. macrochirhus),* largemouth bass *(Micropterus salmoides),* smallmouth bass *(M. dolomieu),* walleye *(Stizostedion vitreum),* and northern pike *(Esox lucius)* were introduced to the upper Hudson in the 20th century.

A 1995 fish community survey of 16 streams conducted for the Hudson River NAWQA program (Wall et al. 1998) showed a positive relationship between the percentage of fish intolerant to impaired water quality (such as brook trout and sculpin) and the percentage of forested or other undisturbed land in the watershed. The absence or rarity of fish intolerant to impaired water quality was associated with chemical and/or habitat impairment more often found in developed watersheds than in forested watersheds.

Murray et al. (1996), also as part of the Hudson River NAWQA program, surveyed benthic invertebrate communities and physicochemical conditions in streams of the Hudson River Basin during 1993. The total number of taxa collected was 122. Taxa richness per site ranged from 9 to 33. An ordination analysis produced four major groups of sites that could be distinguished primarily on the basis of watershed land use: 1) sites in watersheds with a high percentage of urban and (or) residential land and high population density; 2) sites in watersheds with a high percentage of agricultural land; 3) sites in watersheds with a low to moderate percentage of either agricultural or residential land and low population density; and 4) sites in heavily or totally forested watersheds and extremely low population density. These patterns suggest that invertebrate communities in streams of the Hudson River basin are affected by environmental factors associated with land use.

Based on distribution maps of the interim report of the New York State Amphibian and Reptile Atlas (New York State Department of Environmental Conservation 2000), the following is a preliminary list of the potential herptofauna of Saratoga National Historic Park based on occurrences in Saratoga County **(“*“** = presence reported by park staff):

Notophthalmus V. Viridescens (red-spotted newt)*
Plethodon cinereus (northern redback salamander)[t]
Eurycea bislineata (northern two-lined salamander)*
Ambystoma maculatum (spotted salamander)[t]
A.jeffersonianum X laterale (Jefferson salamander complex)*
Gyrinophilus p. porphyriticus (northern spring salamander)[t]
Desmognathus fuscus (northern dusky salamander)[t]
Hyla Versicolor (gray treefrog)[t]
Pseudacris c. crucifer(northern spring peeper)[t]
Rana catesbeiana (bullfrog)*
R. clamitans melanota (green frog)[t]
*R. sylVatica (wood frog)**
R. pipiens (northern leopard frog)[t]
R. palustris (pickerel frog)[t]
Bufo a. americanus (eastern Amercian toad)[t]
Chelydra s. serpentina (common snapping turtle)[t]
Stemotherus odoratus (common musk turtle)
Terrapene c. carolina (eastern box turtle)[t]
Graptemys geographica (common map turtle)
Chrysemys picta (painted turtle)[t]
Clemmys inscuipta (wood turtle)[t]
Clemmys guttata (spotted turtle)[t]
Nerodia s. sipedon (northern water snake)[t]
Thamnophis sirtalis (common garter snake)[t]
I sauritis (eastern ribbon snake)[t]
Heterodon platirhinos (eastern hognose snake)
Storereia dekayi (northern brown snake)*
S.occipitomaculata (northern redbelly snake)*
Liochlorophis Vemalis (smooth green snake)[t]
Lampropeltis t. triangulum (eastern milk snake)[t]

The National Park Service will be conducting an amphibian and reptile survey for the park (C. Martin, 2000, pers. comm., Saratoga National Historical Park) in 2001. This survey will confirm the presence/absence of the above species.

RARE, THREATENED OR ENDANGERED SPECIES

The eastern box turtle *(Terrapene c. carolina),* spotted turtle *(Clemmys guttata)* and wood turtle *(Clemmys insculpta)* (all are state listed as species of special concern) have been reported as present within park boundaries. In addition, based on distribution maps from the New York State Amphibian and Reptile Atlas Project (New York State Department of Environmental Conservation 1998; 2000), the eastern hognose snake *(Heterodon platirhinos),* a state listed species of special concern, may also be found in the park. Two other species of special concern, the blue-spotted salamander *(A. laterale)* and the Jefferson salamander *(A. jeffersonianum),* are know to exist in counties adjacent to the north and south of Saratoga County; however, these species readily hybridize to form a hybrid complex known as the Jefferson salamander complex.

PARK DEVELOPMENT AND OPERATIONS

The park's potable water system provides water to the visitor center, maintenance area, ranger offices and park headquarters; however this system requires constant repairs. There are two drilled 28-foot wells at park tour stop 8, one of which is not functioning. The park maintains 11, 399 feet of 4-inch main water line, nine fire hydrants (one active and eight abandoned), four drinking fountains, and a 35,000-gallon reservoir at the visitor center. Quarters #18 has 1283 feet of 4-inch line connecting to the Schuylerville Village water system. It was installed in 1956 and is in questionable condition. There are five septic systems in the park. All other utilities are acquired commercially.

STAFFING AND ONGOING PROGRAMS

Saratoga National Historical Park has a total of 23 full-time equivalent (FTE) personnel. However, only 1.2 FTEs are allocated to natural resources management for the park or about five percent of the park's total FTE. In addition, the park's GIS program is a collateral duty of the natural resources management program that further restricts the availability of staff and monies. Due to budget constraints and hiring ceilings, the water-quality monitoring program, which collected data beginning in 1987, was discontinued in 1991. Currently, the park is conducting no water quality monitoring or water resource assessment activities.

WATER RESOURCE ISSUES AND RECOMMENDATIONS

DEVELOP COST EFFECTIVE WATER QUALITY MONITORING PROGRAM

While it appears that good water quality exists within the streams flowing through Saratoga National Historic Park, nonpoint source pollutants associated with increasing residential and urban sources could impact existing water quality. These sources include potential contamination from subdivision/ commercial development, runoff associated with agriculture and developed areas, septic system leachate, winter use of salt on roads, and lawn and garden chemicals.

Residential and commercial development often results in the reduction of infiltration areas, which can increase storm water runoff and alter discharge and hydrologic patterns. This, in turn, may lead to additional sediment loading and channel scour in the receiving stream. In addition, improperly designed slope development or poor construction practices can also increase surface erosion and sediment load.

Many residences have expansive lawn areas that undoubtedly receive applications ot lawn chemicals including fertilizers and pesticides. Additionally, the Saratoga Sod Farm is adjacent to the Mill Creek drainage. Little information is currently available regarding the types or amounts of chemicals applied or the potential for runoff of these chemicals into adjacent streams.

Contaminants frequently associated with storm water runoff from commercially developed areas including highways and parking lots include total suspended solids, heavy metals, polycyclic aromatic hydrocarbons and road salts (Ball et al. 1991).

Septic tank leachate presents another possible source of water contamination. Visitor facilities and administration buildings within the park rely on septic systems and leach fields for sewage disposal. Residential development in the surrounding area relies exclusively upon septic systems.

Understanding these potential impacts, the park initiated a baseline surface water-quality monitoring program in 1987. The purpose of this program was to provide a long-term record for a minimal set of key parameters that might serve to flag deteriorating water quality. In addition, the familiarity with stream conditions and visual observations by park staff might prove useful in detecting possible water quality deterioration. Once stream water quality degradation is detected, the park would notify the appropriate regulatory state agency.

This program was discontinued in 1991 due to staff and budget constraints. Given the population growth of the area over the last decade and the strong correlations between water quality parameters and population density through nonpoint source pollution, it is time for the park to initiate a new, cost-effective water-quality monitoring program. Although a program to monitor all of the possible impacts from various nonpoint sources would be extremely costly and is not warranted, the park should initiate a long-term monitoring program designed to: 1) flag potential degradation resulting from nonpoint source contamination; 2) provide a better assessment of baseline water quality; 3) periodically appraise the health of the aquatic ecosystem; 4) incorporate appropriate quality assurance/control procedures; and 5) compare collected data with other existing state and federal monitoring efforts being Undertaken in the vicinity.

The water quality-monitoring program at Saratoga National Historical Park should be constituted as detailed below. This program is very similar to the one developed for the Roosevelt-Vanderbilt historic sites on the lower Hudson River (National Park Service 1 997b). The park is strongly encouraged to consult with Roosevelt-Vanderbilt on all aspects of this proposed program.

The proposed water-quality monitoring program for Saratoga National Historical Park is consistent with guidelines for conducting baseline natural resource inventories in the National Park Service (National Park Service 1993). It includes all of the required parameters (alkalinity, pH, conductivity, dissolved oxygen, temperature, flow, and rapid bioassessment baseline) as well as four of the seven ‘optional’ (or case by case) parameters (turbidity, nitrate/nitrogen, phosphate/phosphorus, and bacteria).

If the Record of Decision on the Hudson River Superfund Site, scheduled for December 2000, determines that some form of remediation is necessary then the water-monitoring program detailed below could be modified by the park. This modification would likely be some form of postremediation monitoring, perhaps done in partnership with other state and federal agencies.

1) The following physicochemical parameters should be sampled on a quarterly basis: dissolved oxygen; temperature; conductivity; total dissolved solids; turbidity; pH; alkalinity; nitrate nitrogen; chloride; and phosphate. Fecal coliform/fecal streptococcus samples should be conducted biannually. In addition, it is important to understand water quality dynamics during significant runoff

events. Therefore, all parameters should be sampled during one significant runoff event per year (called a “floating” sample).

MacDonald et al. (1991) and Sanders et al. (1987) provide good discussions on the frequency of monitoring. Sampling frequency is a function of the statistical objectives of the monitoring project. Any change in the desired accuracy or reliability of the results directly affects the sample size and the choice of parameters.

A monitoring project that is attempting to detect a relatively small change with a high degree of certainty will be more costly than a monitoring program with a lower standard for identifying a statistically-significant change. More measurements will increase the precision and hence the ability to detect change, but the marginal cost and benefit of each additional measurement will vary according to the parameter. All of the above parameters are subject to spatial and temporal variability, and this affects their relative precision and ability to detect change.

The choice of quarterly sampling frequency is based on: a) the amount of staff time, funds, expertise, and equipment needed to make and interpret an individual measurement; and, b) the typical sampling frequency of each of the parameters as discussed in MacDonald et al. (1991). This physicaVchemical sampling framework coupled with some form of biological monitoring should provide the park with an effective early warning system to detect changes from anthropogenic sources. Once detected a more intensive and costly short-term monitoring study may be needed to understand the source(s) of the observed changes.

2) All chemical analyses, i.e., alkalinity, nitrate nitrogen, chloride, and phosphate, and fecal coliform/fecal streptococcus should be analyzed under contract with a local, U.S. Environmental Protection Agency-certified water quality laboratory. Hach kits are notoriously insensitive at low concentrations resulting in analyses that are often below detection limits.

All physicochemical analyses, i.e. temperature, dissolved oxygen, conductivity, total dissolved solids, and turbidity should be conducted in the field using various meters. Again, the Roosevelt-Vanderbilt historic sites should be contacted with regard to purchase and use of these meters.

If population growth and development continues at the present rate, it may become desirable to collect and analyze surface water samples for the presence of organic compounds. Those organic compounds tested should be the suite of chemicals known as Purgeable Aromatic Hydrocarbons, and commonly referred to as BTEX (for benzene, toluene, Qthyl benzene, and xylenes) which are associated with motor fuel contamination (Roy Irwin, personal communication, National Park Service Water Resources Division, 2000).

3) For the present, three monitoring stations should be established: a) on Mill Creek, just downstream of the Saratoga Sod Farm property; b) Kroma Kill, upstream of intersection with the park loop road; and c) Devil’s Hollow, downstream from confluence of the north and south forks.

Because the Old Champlain Canal cuts across the drainages of the park and is at the bottom of the gradients for these drainages, it may act as a pollution sink demonstrating the cumulative impacts of water pollution. Regular water quality monitoring of the Canal is probably not necessary nor is it very informative, i.e. if an assessment of the Canal determines that water quality has deteriorated, one cannot determine which drainage(s) has contributed to this deterioration. However, because the Canal may become a high visitor use area, infrequent monitoring may be necessary. Therefore, the park should consider establishing a monitoring station on the Canal that would be sampled with a frequency of once every 2 to 3 years. Such monitoring would be limited to the parameters mentioned under ‘1’ above.

Park staff have expressed concem that the application of pesticides on the Saratoga Sod Farm may be impacting park water resources. Regular monitoring or pesticide concentrations in surface waters is expensive especially it one does not know the kinds ot pesticides being used, as is the case here. If the park can determine the pesticide(s) in use by the sod farm, it would be informative to conduct ‘snapshoi monitoring (once every 5 years) of the pesticide(s) concentration in the surface water at the Mill Creek station. This monitoring should be conducted towards the end of the growing season.

4) Stream discharge is a parameter that should be measured at each of the above monitoring stations. A stage-discharge relation should be established at these stations. Staff gages will need to be installed and a rating curve developed for each gaging site. This may require purchase or long-term loan of a flow meter. The purchase price of a quality flow meter ranges from about $1000 to $3000.

At each of the stations, a general reconnaissance should be made so that the most suitable site for the gage is selected. In selecting a site consideration should be given to the following items (Carter and Davidian 1968):

- channel characteristics;
- possibility of backwater from downstream tributaries or other sources;
- availability of a nearby cross section where good discharge measurements can be made;
- proper placement of a stage gage with respect to the measuring section and to that part of the channel which controls the stage-discharge relation; and,
- possibility of flow bypassing the site in groundwater or in flood channels.

The stage of a stream is the height of the water surface above an established datum plane. Measurements of stream stage are used in determining records of stream discharge. A record of stage can be obtained by systematic observations of a non-recording stage. The advantages of the non-recording gage are the low initial cost and the ease of installation. For example, attach a staff gage to a steel fence post and drive it into the stream bed so that some part of the scale is still immersed at the lowest expected water level of the sampling period and the top of the scale protrudes above the water at the highest level.

The frequency of the staff gage readings is determined by accuracy requirements and the degree of expected water-level fluctuations. When unexpected alterations in the water supply occur that affect water level, a change in the predetermined visiting schedule is warranted.

Discharge measurements are normally made by the current-meter method, which consists of determinations of velocity and area in the parts of a stream cross section. The following is taken from Carter and Davidian (1968):

> the cross section is divided into 20-30 partial sections (this will depend on stream width), and the area and mean velocity of each is determined separately. A partial section is a rectangle whose depth is equal to the sounded depth at the meter location (a vertical) and whose width is equal to the sum of half the distances to the adjacent verticals. At each vertical the following observations are made: (1) The distance to a reference point on the bank, (2) the depth of flow, and (3) the velocity as indicated by current meter at one or two points in the vertical. These points are at either the 0.2 or 0.8 depths (two-point method) or the 0.6 depth (one-point method) from the water surface. The average of the two velocities or the single velocity at 0.6 depth, is taken to be the mean velocity in the vertical. The discharge in each partial section is computed as the product of mean velocity times depth at the vertical times the sum of half the distances to adjacent verticals. The sum of the discharges in all the partial sections is the total discharge of the stream.

Determination of discharge at a large majority of gaging stations is a result of the relationship between stage and discharge. These stage-discharge relations are rarely permanent, particularly at low flow, because of chanaes in the stream channel such as scour and fill. aauatic arowth. ice, or debris or because of changes in bed roughness. Frequent discharge measurements are necessary to define the stage-discharge relationship at any time.

The stage-discharge relationship is developed from a graphical analysis of the data plotted on either rectangular-coordinate or logarithmic plotting paper. Kennedy (1984) provides an in depth discussion for determining the stage-discharge relationship. Stage is plotted on the abscissa and discharge on the ordinate of log-log paper, or a least-squares equation is calculated from these data pairs. Subsequent estimations of discharge require only a stage measurement, which is used on the plotted curve or in the regression equation to calculate discharge.

5) During the quarterly sampling of each monitoring station, black and white photographs should be taken looking upstream and downstream of each station. Photographic monitoring is an inexpensive method to assess changes in stream geomorphology, the riparian zone, and other physical habitat features that may be associated with site and watershed conditions. A series of photographs would also allow detection of slow, progressive changes in physical habitat features that otherwise might go undetected until the accumulation of impacts is noticeable.

6) Biological assessments should be conducted at each of the monitoring stations on an annual basis or, at least every 2 years.

The phrase biological integrity was first used in 1972 to establish the goal of the Clean Water Act: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." This mandate clearly established a legal foundation for protecting aquatic biota. Unfortunately, the vision of biological integrity was not reflected in the act's implementing regulations. Those regulations were aimed at controlling or reducing release of chemical contaminants and thereby protecting human health; the integrity of biological communities was largely ignored (Karr 1991). As a result, aquatic organisms and aquatic environments have declined in recent decades. The assessment of water resources extends beyond pollutant-caused degradation of water quality; in addition, we face loss of species, homogenized biological assemblages, and lost fisheries.

Biological integrity refers to the capacity to support and maintain a balanced, integrated, and adaptive biological system having the full range of elements (e.g., populations, species, assemblages) and processes (e.g. biotic interactions, energy dynamics, biogeochemical cycles) expected in a region's natural habitat (Karr et al. 1986). The biological integrity of water resources is jeopardized by altering one or more of five classes of environmental factors: alteration of physical habitat, modifications of seasonal flow of water, changes in the food base of the system, changes in interactions within the stream biota, and chemical contamination (Karr 1991). Urbanization, for example, compromises the biological integrity of streams by severing the connections among segments of a watershed and by altering hydrology, water quality, energy sources, habitat structure, and biotic interactions.

Water managers are increasingly being called upon to evaluate the biological effects of their management decisions, for no other aspect of a river gives a more integrated perspective about the condition of a river and its biota. Widespread recognition of this and the continued degradation of our water resources have stimulated numerous efforts to improve our ability to track aquatic biological integrity (Davis and Simon 1995). Comprehensive, multimetric indexes (Barbour et al. 1995) were first developed in the Midwest for use with fishes (Karr 1981; Fausch et al. 1984; Karr et al. 1986), and modified for use in other regions of the U. S. (Miller et al. 1988) and with invertebrates (Ohio EPA 1988; Plafkin et al. 1989; Kerans and Karr 1994; Deshon 1995; Fore et al. 1996). The conceptual basis of the multimetric approach has now been applied to a variety of aquatic environments (Davis and Simon 1995), including large rivers, lakes, estuaries, wetlands, riparian corridors, and reservoirs, and in a variety of geographic locations (Lyons et al. 1995).

Presently, more comprehensive approaches have been developed and are being adopted by state and federal agencies. Forty-two states now use multimetric biological assessments of biological condition and six states are developing biological assessment approaches; only three states used multimetric biological approaches in 1989 (U.S. Environmental Protection Agency 1996b). Efforts are at last being made to monitor the biological integrity of water resources as mandated by the Clean Water Act 28 years ago (Karr 1991; Davis and Simon 1995; U.S. Environmental Protection Agency 1996b).

The set of metrics incorporated into a multimetric index integrates information from ecosystem, community, population, and individual levels (Karr 1991; Barbour et al. 1995). Multimetric indexes are generally dominated by metrics of taxa richness (number of taxa) because structural changes, such as shifts among taxa, generally occur at lower levels of stress than do changes in ecosystem processes (Karr et al. 1986). However, the most appropriate and integrative multimetric indexes embrace several concepts, including taxa richness, indicator taxa or guilds (e.g. tolerant and intolerant), health of individual organisms; and assessment of processes (e.g., as reflected by trophic structure) of the sampled assesmblage.

Like the multimetric indexes used to track national economies, multimetric biological indexes measure many dimensions of complex ecological systems (Karr 1991). Multimetric economic indexes assess economic health against a standard fiscal period; indexes of biological integrity assess the biological well being of sites against a regional “baseline condition” reflecting the relative absence of human influence. The goal is to understand and isolate, through sampling design and analytical procedures, patterns that derive from natural variation in environments.

The systematic, biological assessment of species assemblages using multimetric indexes is presently the one of the most practical and cost-effective approachs to determine if human actions are degrading biological integrity is (Davis and Simon 1995). Such monitoring provides both numeric and narrative descriptions of resource condition, which can be compared among watersheds, across a single watershed, and over time (Karr 1991), and it does so at costs which are often less than the cost of complex chemical monitoring. Costs per evaluation are low for ambient biological monitoring (based on a decade of sampling and including equipment; supplies; and logistical, administrative, and data analysis and interpretation activities: benthic invertebrates, $824; fish, $740; Yoder and Rankin 1995) in comparison with chemical and physical water quality ($1,653) and bioassays ($3,573 to $18,318).

The biological assessment on Crum Elbow Creek at the Home of Franklin D. Roosevelt National Historic Site by Bode et al. (1995) is an excellent example of the use of the multimetric approach using benthic invertebrates. This assessment used standardized methods for sampling and analysis and has been quality assured (Bode et al. 1991). It uses four metrics: species richness, EPT value (total number of mayllies, stoneflies, and caddisflies; Hilsenhoff Biotic Index (measure of pollution tolerance of the sampled organisms); and Percent Model Affinity (see Novak and Bode 1992). The description of overall stream water quality based on these biological parameters uses a four-tiered system of classification (non-impacted, slightly impacted, moderately impacted, and severely impacted). The level of impact is assessed for each metric and then combined for all metrics to form a consensus determination. The consensus is based on the determination of the majority of the metrics; since metrics measure different aspects of the invertebrate community, they cannot be expected to always form unanimous assessments.

Percent model affinity compares a benthic macroinvertebrate community in sampled waters to an ideal, or “model” benthic macroinvertebrate community. The metric is based on the premise that the biological effects of pollutants can be measured by comparing an existing macroinvertebrate community with an expected community.

The analysis of benthic macroinvertebrate communities has been quite successful in determining the severity of water quality impacts. It has been less effective in determining the type of pollution causing the impact. Bode (U.S. Environmental Protection Agency 1 997b) has developed a new metric, called the impact source determination, that determines the type of impairment. This metric compares test data to model communities impacted by various known impacts. It was developed from a large macroinvertebrate database to distinguish seven categories of impact: nonpoint nutrient additions, toxic, sewage effluent, municipal/industrial, siltation, impoundment, and natural or nonimpacted. The model that exhibits the highest percentage similarity to the test data denotes the likely impact source type.

Saratoga National Historic Park is encouraged to obtain training from the New York State Department of Conservation (Bode et al. 1995) in aquatic macroinvertebrate sampling, identification, and analysis. The park could then either conduct its own biological assessment program, conduct the sampling and contract out to the state for the identification and analysis phases, or just contract out to the state to do all phases (sampling, identification, and analysis) at the three sites. If the state is unable or unwilling to perform all or part of the needed biological assessments, a local environmental consulting firm could also be contracted to conduct the sampling and analysis using the state's approach. The use of this approach is the most cost-effective simply because the state has been using the approach since 1988 and has gone through the trial and error phase. While there may be other candidate approaches, these would have to be tested for applicability to the upper Hudson River drainage and may have to be modified. This would require substantial, upfront costs and time commitments prior to any use of a new approach.

7) Given the above program, a water quality monitoring plan should be developed. Sanders et al. (1987) and MacDonald et al. (1991) provide excellent discussions on monitoring plans or aspects of these plans. In addition, the Water Resources Division can assist the development — probably through technical assistance.

This monitoring plan should establish a quality assurance/quality control program. This program would include, at the least, the delineation of field sampling and laboratory analytical methods, data storage and retrieval methods, and data analysis and interpretation. In particular, the park is encouraged to use its capability in GIS as a data analysis and interpretation tool.

Annual summary reports should be prepared. These reports should include the tabular presentation of the data, data analysis, and data interpretation. For a variety of reasons many monitoring programs do not follow through to this step, and in such cases the worth of conducting the monitoring program must be questioned. In general, the multiple demands on staff time mean that the monitoring data will be used only if they are summarized and interpreted. The data are more likely to be evaluated by managers and used for the original purpose, namely the guidance of management decisions. The Water Resources Division can review these reports. These reviews will act as a feedback loop that provides input into the continued adequacy of the monitoring program.

These annual summary reports should be shared with other federal, state, and local agencies, as applicable. This will facilitate discussions with appropriate regulatory authorities when corrective action is necessary.

8) The Victory Woods property apparently has more historical significance than previously thought (Saratoga National Historical Park *in prep.).* As such the general management plan may propose that this site be interpreted and visitor facilities developed. In anticipation of such a proposition the park is concerned that baseline water quality information be collected prior to any development.

The only water resource on this parcel is a large wetland, probably formed from natural spring seepage. Because redoubts were built around this wetland area, it would appear that this wetland was extant during the time of the battles. Victory Woods is surrounded by housing that no longer treats sewage via septic tanks/leach fields. Therefore, any potential impacts from leaking onsite systems have been reduced. However, if onsite systems are still in place, remnant pollution could be taking place.

This isolated wetland could harbor rare flora and fauna. The park is encouraged to conduct a basic survey of the aquatic species of this wetland. At the same time those parameters identified in items 1 and 2 (see above) should be measured. Depending on the outcome of these surveys, additional sampling may be required.

Because the above changes require a further commitment of park resources, Project Statement SARA-N-000.001 (Appendix A) addresses the development of the water-quality monitoring program and the concomitant resource needs.

Victory Woods wetland

PRICE FARM AND SCHUYLERVILLE REFUSE DUMPS

The Price Farm dump is located on a cut bank of the North Fork of Devils Hollow (Figure 2). Most of the refuse is located on the stream bank but a portion is on the immediate floodplain. The pile consists of visible, miscellaneous domestic and farm wastes with an area of approximately 40,000 square feet. All dumping at the site took place prior to acquisition of the land by the National Park Service in 1986. Details of specific activities on the site prior to acquisition are not available. The site has not been used for refuse disposal since federal acquisition. Access by park personnel and visitors are limited.

In 1993 the Water Resources Division of the National Park Service conducted a preliminary site assessment for hazardous materials at the Price Farm dump (Martin 1994). The broad purpose of a preliminary site assessment is to determine from readily available evidence if a site potentially containing hazardous substances poses a human health or environmental threat great enough to warrant a detailed investigation. The specific purpose of this preliminary assessment was to assess the potential threat from farm and household waste in the Price Farm dump to natural and historic resources and resident and visiting populations of the park.

Environmental threat scores were determined for the ground water, surface water, soil exposure, and the air pathways by evaluating the likelihood of release, coupled with primary and secondary targets in the form of water users, nearby residents, and sensitive environments on each of the four pathways.

Although a release to ground water was hypothesized, the actual extent of ground water contamination was believed to be low. The site is underlain by discontinuous alluvial material that overlies shale bedrock, and while the bedrock may transmit some water through fractures, yields from bedrock wells are generally low and depths are shallow. The nearest wells, which are about 1300 ft to the north-northwest are finished in bedrock and therefore subject to fracture flow. In an aquifer where flow is controlled completely by fractures, the direction of groundwater flow depends on the direction of the fractures (Fetter 1994). Therefore, in order for a bedrock well to be contaminated by leachate from the site it would have to be finished in fractures on a direct flow path, and down the hydraulic gradient from the Price Farm Dump. The presence of perennial baseflow and springs in Devils Hollow indicates that this is an area of ground water discharge, and therefore of lower hydraulic gradient. For these reasons, the nearest wells were considered unlikely to be contaminated by leachate from the site.
Release to the alluvial ground water underlying the site has likely taken place, but the alluvial aquifer is not continuous and has no wells nearby so exposure of targets from ground water withdrawn for the alluvium was considered very unlikely.

As far as surface water, overland drainage from the dump site has the potential to flow about 30 feet to the North Fork of Devils Hollow Creek, although no well defined surface route exists. A more likely means of entry into the surface water environment is from infiltration into the shallow alluvium with subsequent discharge into the creek. Wetlands exist in the immediate vicinity of the dumpsite and extend for approximately 0.25 mile downstream. However, there were indications of a contaminant release to surface water and the surface water pathway posed the greatest environmental threat through exposure of sensitive environments.

The preliminary assessment site score fell below the “no further remedial action” benchmark and indicated that the site evaluation of the refuse pile and the surrounding area is complete, and that additional investigation or remediation is at the discretion of the National Park Service. Regardless of this fact, it was recommended that a chemical analysis be performed on samples from all park wells in the vicinity of the site. The wells located to the north and northwest along Route 32 are unlikely but possibly affected by effluent from the site, and warrant analysis for metals and organics.

Based on this recommendation, the park collected water samples from the “Chateau Garden” well adjacent to Route 32 in 1995. An independent laboratory analyzed water samples for the suite of chemicals collectively known under U.S. Environmental Protection Agency Standard Methods 8240 (36 chemicals) and 8270 (49 chemicals) (CTM Analytical Laboratories 1996). Only two chemicals were detected. One of the chemicals, acetone, is a common laboratory artifact for volatile organics analysis, and it was only slightly larger than the ‘practical quantification limit’ for acetone. The other chemical, carbon disulfide, was present at a concentration 22 times its ‘practical quantification limit.’

Carbon disulfide is used in a number of industrial applications (U.S. Environmental Protection Agency 1 998a). The largest use of carbon disulfide is as a reactant in the manufacture of rayon fibers. It is also used in the production of cellulose; in agricultural fumigants; in the production of rubber chemicals; as an agent in metal treatment and plating; as a solvent for cleaning and extraction; in the production of adhesives; and, as an extractant for olive oil. Considering that the immediate area over and adjacent to the “Chateau Garden” well was used previously as an automotive garage (Chris Martin, personal communication, 1997, Saratoga National Historical Park), the likely source of carbon disulfide is from its use as a cleaning solvent. Another possibility is from the local use of agricultural fumigants.

In 1994 the park personnel took a total of 15 soil surface and core samples from the dump area itself and adjacent to the North Forth of Devils Hollow. An independent laboratory analyzed these samples for volatiles (U.S. Environmental Protection Agency Standard Methods 8010/8020), semi-volatiles (8270/8080), and metals (Upstate Laboratories 1994).

Tetrachloroethene, a commonly used degreasing solvent, arsenic (naturally occurring and found in pesticides), and mercury were present in almost all core samples. Tetrachloroethylene was present in all samples with highest concentrations at those sample sites adjacent to the creek. Concentrations ranged from 15 to 41 ppb at the surface, 6 to 19 ppb at 0.5 feet in depth, and 3 to 5 ppb at 3.0 feet in depth. Mercury (present in eight of 15 samples) also showed highest concentrations from those samples taken adjacent to the creek, and ranged from 28 to 54 ppb at 0.5 feet in depth and 24 to 31 ppb at 3.0 feet in depth. Arsenic was present in all samples, but showed no marked distinction in areal concentration. It ranged from 3.4 to 15 ppm. Upstate Laboratories (1994) concluded that, depending upon the exposure to humans from tetrachloroethene, mercury, and arsenic, the New York Department of Health may or may not choose to have this site remediated. Freon (dichlorodifluoromethane), commonly used in the refrigeration industry, was present in four samples (concentration ranged of 13 to 21 ppb) and methylene chloride, also commonly used as a degreaser, was present in a two samples (13 to 14 ppb). Upstate Laboratories (1994) concluded that all levels were low enough and should not pose a problem.

Tetrachloroethylene is a carcinogenic priority pollutant and is used in dry cleaning and as an industrial solvent (Irwin et al. 1997). Much of the tetrachloroethylene that gets into water and soil will evaporate to the air. If tetrachloroethylene is released to water, it will be subject to rapid volatilization with estimated half-lives ranging from less than one day to several weeks. However, because tetrachloroethylene can travel through many soils quite easily, it can get into ground water supplies. It is not expected to significantly biodegrade, bioconcentrate in aquatic organisms or significantly adsorb to sediment.

Effects of this volatile solvent to the biota would often result from high concentrations immediately after a spill or be the indirect result of contamination of groundwater. For example, if highly polluted ground water comes into surface waters from springs or seeps, local effects may occur in the mixing zone where the ground water enters surface water.

One potentially important aspect of the presence of tetrachloroethene is that it can break down into other hazardous compounds. Tetrachloroethene can be transformed by reductive dehalogenation to trichloroethylene (TCE), dichloroethylene, and vinyl chloride under anaerobic conditions. Thus, when tetrachloroethylene levels have been reduced to acceptable levels, it is still necessary to check to see that levels of the suspected hazardous breakdown products are also acceptably low.

Surface water samples and sediment from unpolluted areas are usually less than 1 ppb and 5 ppb, respectively. Insufficient data exist to determine water quality criteria; however, freshwater acute and chronic LOELs (lowest observed effect levels) are 5,280 and 840 ppb. The U.S. Environmental Protection Agency drinking water maximum contaminant level is 5 ppb. Region Ill of the U.S. Environmental Protection Agency in 1995 determined that the risk-based concentration to protect from transfers to ground water is 0.04 mg/kg dry weight.

Methylene chloride is a colorless liquid that evaporates rapidly when exposed to air and dissolves easily when mixed with water (U.S. Environmental Protection Agency 1 998b). Its primary industrial and consumer uses are as a solvent in paint stripping or metal cleaning (degreasing).

Most of the methylene chloride released to the environment is likely to end up in air. Methylene chloride evaporates from water exposed to air. It is likely to move through the ground if it is released to and covered by soil. Once in ground water methylene chloride is expected to remain for long periods of time unless it is broken down to simpler chemicals by microorganisms.

At the low levels usually found in the environment, methylene chloride does not appear to cause adverse environmental affects. It is toxic to aquatic or terrestrial animals only at high levels. The maximum concentration level in drinking water for methylene chloride is 0.005 ppm. The ambient water quality criterion for human health (water and fish consumption) is 0.0002 ppm. There are no ambient water quality criteria for aquatic life.

Arsenic is listed by the U.S. Environmental Protection Agency as one of 129 priority pollutants, lamong the 25 hazardous substances thought to pose the most significant potential threat to human health at priority superfund sites, and designated a toxic pollutant pursuant to section 307(a) (1) of the Clean Water Act (Irwin et al. 1997). Arsenic has long been a concern to humans because small amounts can be toxic. Indeed, arsenic is often thought of as a carcinogenic priority pollutant.

Arsenic is volatilized from the soil as arsine, which is produced through chemical reduction by soil microorganisms. Arsenic is also lost from surface soils through leaching. The amount removed by leaching is related to the solubility of arsenic, which is greater in sandy or low-clay soils. The solubility of arsenic in reduced by the adsorption of arsenic onto organic matter and charged surfaces of clays and the binding of arsenic to metallic compounds.

Arsenic is very mobile in the environment. Complex conditions in the sediment, soil, air, water and organisms in which chemical and/or biochemical processes take place govern the transport of arsenic. Rocks are a natural source of arsenic, but rivers seem to cleanse themselves of soluble arsenic.

The breakdown of arsenic compounds stops with the elemental arsenic, so many remediation efforts are aimed at immobilizing (often by combination into less soluble compounds) or removing arsenic to hazardous waste sites. Surface and ground water as well as wind-blown dust are important media for arsenic transport pathways

Arsenic is one of the most toxic elements to fish. Acute exposures can result in immediate death because of arsenic-induced increases in mucus production, causing suffocation, or direct detrimental effects on the gill epithelium. Chronic exposures can result in the accumulation of the metalloid to toxic levels.

The median arsenic concentration for surface water samples recorded in the U.S. Environmental Protection Agency's STORET database is 3 ppb. Arsenic levels in ground water average about 1 to 2 ppb. The acute freshwater criterion is 0.0036 ppb and the chronic freshwater criterion is 0.0019 ppb.

The U.S. Environmental Protection Agency lists mercury as one of 129 priority pollutants (Irwin et al. 1997). Mercury is one of the few metals that strongly bioconcentrates and biomagnifies, has only harmful effects with no useful physiological functions when present in fish and wildlife, and is easily transformed from a less toxic inorganic form to a more toxic organic form. One organic form of mercury, methylmercury, is of particular concern because it can build up in certain fish. Mercury is the heavy metal most toxic to fish.

Mercury released into the environment remains for a long time. Once in the environment, mercury can slowly be changed from organic to inorganic forms and vice versa by microorganisms and natural chemical processes. Methylmercury is the organic form of mercury created by these natural processes.

In 1996 the park had three surface water samples (upstream of dump, at dump, and downstream of dump) from the North Fork of Devils Hollow analyzed by an independent laboratory (CTM Analytical Laboratories 1996). One hundred and six chemicals were analyzed representing, for example, such Standard Methods as 8010, 8020, 8270, and metals. None of these 106 chemicals was detected from any of the water samples.

The preliminary assessment combined with the subsequent analyses was submitted to the U.S. Environmental Protection Agency for review. The U.S. Environmental Protection Agency determined that a Site Inspection was needed. An independent contractor completed a Site Investigation of the dumpsite in 1998 (Program Management Company 1998). No Target compound List volatile organic compounds, semi-volatile organic compounds, pesticides/PCB5 or Target Analyte List (TAL) metals were detected in soil samples that exceeded the Risk Based Concentrations developed by Region Ill of the U.S. Environmental Protection Agency (October 1, 1998). None of the above except TAL metals was detected in either surface or ground waters. Aluminum, iron, manganese, arsenic and lead exceeded the respective Risk Based Concentrations (RBC) at each of three ground water sample locations. Cadmium and chromium exceeded the respective RBC at two locations, and barium and vanadium exceeded the respective RBC at one location. However, these industrial RBCs are based on ingestion of tap water and neither surface nor ground water is used as a potable source at this site. In addition the nearest wells are 1300 feet north-northwest of the site and completed in bedrock. These metals were also detected in background soil borings, suggesting that they occur naturally at the site.

Program Management Company (1998) concluded that the exceedances of RBCs present an overly conservative scenario and no further investigation appears warranted. The U.S. Environmental Protection Agency (2000), in its review of the Site Investigation, concurred with Program Management Company's conclusion by giving the Price Farm Dumpsite a designation of 'No Further Remedial Action Planned.' Therefore, no further action is required by the park. However, the U.S. Environmental Protection Agency recommends that the remaining waste source materials be removed and the site remediated in such a way that is consistent with the site's use as a national park.

A 2.8-acre parcel of land near the Schuyler House in Schuylerville, NY is commonly referred to by the park as the Schuylerville Dump (Figure 12). This property constitutes an approximately 1,100 feet long by 100 feet wide section of the former Champlain Canal (abandoned in the 1920s), and consists of the bed, banks, top, and towpath of the former canal. The property is state-owned, vacant and consists of mixed vegetative growth, and an assortment of what appears to be old and inert household garbage. The property is located east of Route 4, approximately 1/8th mile south of the Village of Schuylerville. The Schuyler House borders the north end of the property; additional NPS property borders to the east and west. The property was used as an informal, unofficial dumping spot from the 1930s to 1960s.

In 1995, an independent contractor conducted an environmental site assessment with the purpose to determine the presence or likely presence of any hazardous substances on park property (the LA Group 1995). The report concluded that there exists a potential for environmental contamination and recommended that soil samples be analyzed for metals, semi-volatile compounds (Standard Method 8270) and volatile organic compounds (EPA Method 8240) in accordance with Toxicity Characteristic Leaching Procedure (TCLP). The TCLP analysis indicates whether the soil quality has been affected and whether hazardous soil exists at the site. This recommendation was based on visual observations of potential petroleum waste, construction and metal debris, and knowledge that commercial waste may have been dumped on the property. No ground water or surface water testing was recommended at that time.

In 1995 fifteen soil samples were analyzed for the above recommended constituents at three sites (3 sites X 5 samples at various depths/site = 15 samples) (CTM Analytical Laboratories 1996). One site was located in the Old Champlain Canal (on state-owned property) and the other two sites (on NPS-owned property) were adjacent to the old canal. Soil from these sites yielded primarily arsenic (present in all 15 samples ranging from 7.0 to 18.4 ppb) and mercury (present in 4 samples, 0.12 to 0.28 ppb) with toluene, trichloroethene, and fluoranthene present in only one sample each.

The sample size for arsenic and its range of concentrations are comparable to that for the Price Farm Dump. Mercury concentrations are an order of magnitude lower than those found for mercury at the Price Farm Dump. For perspective the risk based concentration (RBC) to protect from transfers to ground water for arsenic and mercury as developed by Region Ill of the U.S. Environmental Protection Agency (1995) are 15 ppm and 3 ppm, respectively. However, without further sampling and analysis, it is not possible to determine whether arsenic and mercury have migrated to ground water or other media.

This state-owned property is on the park’s land protection priority list (National Park Service 1988). Given the presence of two priority pollutants (arsenic and mercury) in a location on the Hudson River floodplain, further investigation would appear warranted. Prior to any future acquisition of this property by the NPS, additional studies, probably in the form of a Site Investigation, would be needed to determine the nature and extent of these and other hazardous substances.

ABANDONED WATER WELLS

Within the park there are numerous wells, most of which were developed prior to 1900 (Figure 13) and were primarily dug wells. All of the pre-1900 wells are abandoned. Only two post-i 900 wells exist: the potable water supply well just off Tour Stop 8 and the Chateau Garden well off of Route 32 (Figure 13). At the start of this plan the park expressed the desire to abandon and plug the Chateau Garden well. This was accomplished in 1999.

The pre-1900, dug wells, some of which date to the days of the battles, are important elements of the cultural landscape and are historic structures that fall under the National Historic Preservation Act and the authority of the State Historic Preservation Officer. As such, typical abandonment procedures of the New York Department of Environmental Conservation do not apply simply because they would be too intrusive and may damage these structures and the surrounding area.

The park should examine each of these dug wells for evidence of any seepage or standing water. Any wells with those characteristics are potential dispersal avenues for any surface pollution much like for drilled wells with deteriorated casings or plugs. The New York Department of Environmental Conservation abandonment objective for water table wells such as these is to prevent the percolation of the surface water through the well structure. Working in concert with the State Historic Preservation Officer and the New York Department of Environmental Conservation, the park should determine the most appropriate method to prevent surface water percolation and still maintain the historic fabric.

Finally, park staff should complete a New York Department of Environmental Conservation record search for all wells in the park. It is possible that unknown wells exist that may need to be abandoned in accordance with State procedures.

BEAVER RECOLONIZATION OF MILL CREEK, KROMA KILL AND THE CHAMPLAIN CANAL

Beaver have recolonized the upper Mill Creek drainage, lower Kroma Kill and the Champlain Canal in Saratoga National Historical Park (Figure 2). Park staff have expressed concern that beaver dams, built using road culverts as part of the infrastructure, may cause flooding

Figure 12. Location of the of the Schuylerville Dump in relation to the Schuyler House in the Village of Victory.

problems. in addition tnose dams on trie unampiain eanai may exacerbate me spring tiooding on Route 4. The park has already eliminated the ponding caused by the dams on upper Mill Creek. However, beaver will undoubtedly continue to recolonize areas of the park. Although traditionally considered a nuisance species, the beaver and its actions affect the general ecology of an area in many beneficial ways. An understanding of the ecology of the beaver is necessary before any attempts at control or removal are made.

The North American beaver *(Castor canadensis)* has historically been one of the most important keystone species because it fundamentally influences the ecology of headwater streams and adjacent riparian areas. Excellent reviews on the impacts of beavers on small stream ecology can be found in Hammerson (1994) and Olson and Hubert (1994) (Table 3). In general a beaver pond tends to shift a stream from a running water ecosystem to more of a shallow lake environment. Locally, the beaver ponds trap sediments and organic matter, and increase algal productivity. Beaver ponds help retain and store small floods, but the dams can washout during extreme floods and thereby increase downstream flood damage. The dams often raise the local water table, and create a greater connection with the floodplain. Beaver activity breaks the forest canopy, but the ponding water often kills other trees whose roots cannot tolerate inundation. These conditions, in turn, favor the growth of riparian tree species such as alders and willows, which are the preferred food source for the beaver. The patches, edges and dead standing trees can result in a three-fold increase in songbird species (Medin and Cleary 1990) and can dramatically enhance amphibian and mammal habitat as well (Olson and Huber 1994).

Beaver dams function much like a stormwater pond and exert a similar influence on downstream water quality. For example, Maret et al. (1987) found that beaver pond complexes sharply reduced total suspended solid concentrations, and reduce phosphorus and nitrogen by 20 to 50 percent. Beaver ponds are usually an effective buffer and tend to increase the pH of water.

At the same time, beaver ponds increase downstream water temperature that can adversely affect trout populations at lower elevations and latitudes. In addition, decomposition and microbial action occurring within the beaver pond, typically lowers the dissolved oxygen content downstream. The aquatic insect community often becomes less diverse both within and below beaver ponds, with running-water species being replaced by pond taxa (Smith et al. 1991).

Beaver dams act as important retention devices, counteracting the tendency for export to dominate the fate of organic matter in flowing water. These obstructions clearly play a significant role in ecosystem function, allowing organic matter to accumulate. This enhances ecosystem processing relative to downstream export, and perhaps favors the formation of localized hotspots of biological activities. In the absence of retention devices the stream functions more like a pipe, allowing inputs to be flushed from the system, including a higher fraction of particulates.

Historical arguments against beaver include dead timber being an eyesore, blocked fish migration, and increased mosquito production. However, the greatest damage associated with beavers is the ponding behind the dam, flooding when the dam is breached, or blockage of culverts (Kwon 2000). With respect to the latter, the beaver can quickly plug up a culvert and backwater up to form a pond. The culvert will no longer convey runoff from large storm events, increasing the probability that the road will be flooded or the earthwork washed out.

Management alternatives to eliminate or discourage beavers generally fall into two categories: beaver removal or water level control. Neither of these categories has proven to be completely

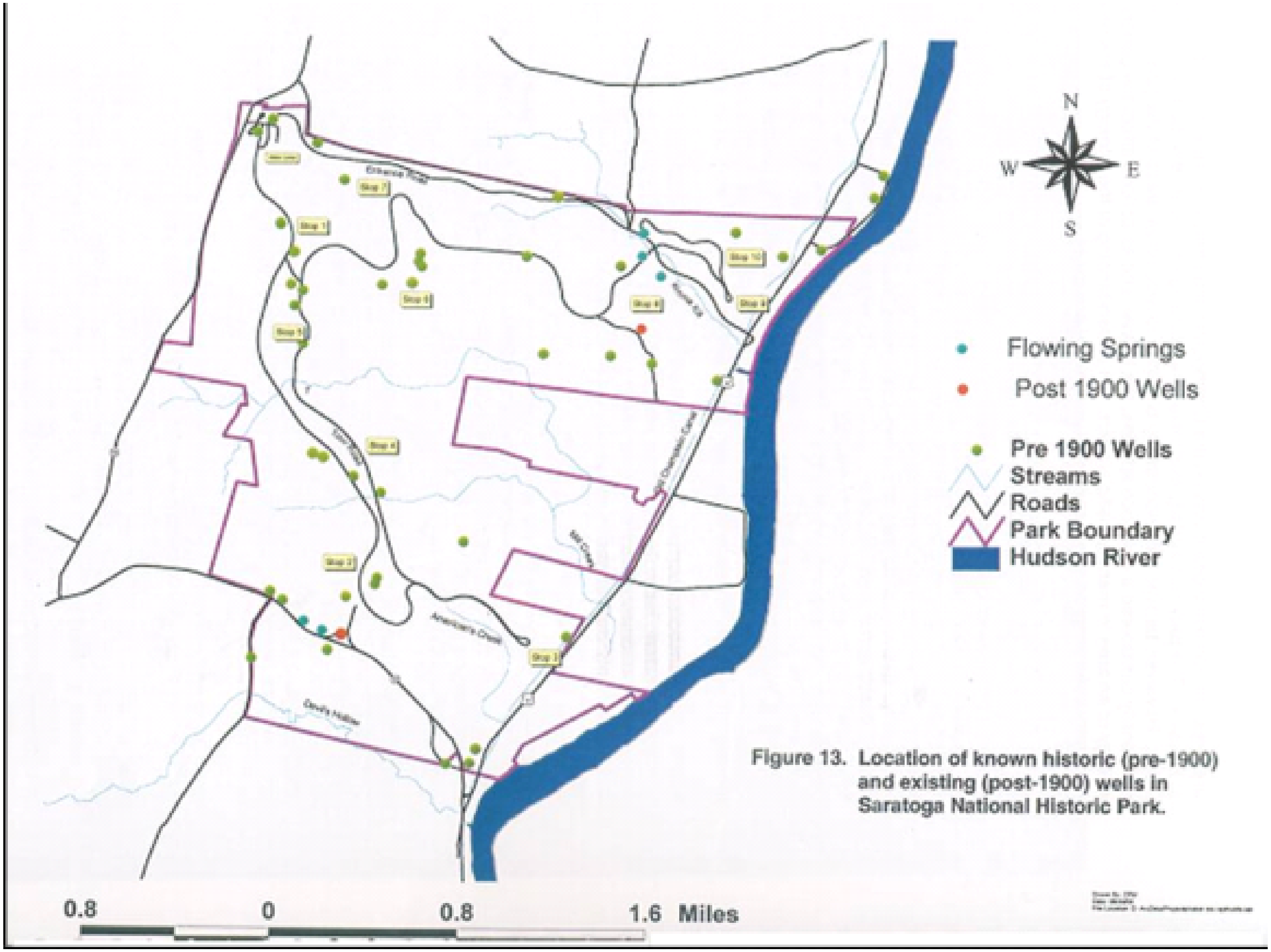

Figure 13. Location of known historic (pre-1900) and existing (post-1900) wells in Saratoga National Historic Park.

Beaver dam at Mill Creek

Table 3. Local or downstream changes caused by beaver dams (modified from Hammerson 1994).

1. Storage of precipitation, gradual release during dry weather
2. Reduced current velocity
3. Increase in wetted surface area of channel by several orders of magnitude
4. Increase water depth
5. Higher elevation of the local water table
6. Decrease in amount of forest canopy
7. Loss of habitat for species that depend on live deciduous trees
8. Enhanced or degraded fish habitat and fisheries
9. Creation of habitat of species that prefer ponds, edges and dead trees
10. Shift of aquatic insect taxa within pond to collectors and predators, and away from shredders and scrapers typical of small streams
11. Increase in aquatic insect emergence per unit length of stream
12. Increase in algal productivity
13. Increase in trapping of sediment and decreased turbidity
14. Favorable conditions for willow and alder
15. Increased movement of carbon, nitrogen, and other nutrients into streams
16. Reduced stream acidity (i.e. higher pH)
17. Lower oxygen levels in the spring and early summer due to decomposition
18. Increased resistance to ecosystem perturbation

effective, i.e. they can reduce beaver damages but seldom can reduce beaver populations. Muller-Schwarze (1979) listed five population management alternatives for Acadia National Park:

1. Non-interference (allow the population to fluctuate with the available habitat).
2. Regulated harvest by commercial trappers.
3. Harvest by park personnel.
4. Live-trapping and transplanting on an annual basis.
5. Large scale beaver sterilization.

At Acadia, the park adopted a modified alternative 1 by managing water levels and allowing beaver to utilize the available forage, thus reducing the suitability of the area for beaver in the future. Alternatives two and three were rejected as contrary to NPS policy. Alternative four was determined to be unfeasible from the standpoint of time and money. Alternative 5 was determined to be unwarranted by park officials.

The majority of beaver problems are created by rising water levels caused by the dam or plugging of a road culvert. Dam destruction (by dynamite or manually) seldom works, unless all beavers are trapped or removed.

An alternative approach is to drain the pond by installing a pipe under the dam or through a clogged culvert. This approach is simple and can work fairly well if the intake is well protected. Otherwise, beavers will try to plug it up with mud and wood to restore water levels, so protective measures are needed.

D'Eon et al. (1995) reviewed a handful of pipe schemes to control water levels and one of the most effective appears to be the Clemson Beaver Pond Leveler. The idea behind this pond leveler is to keep the rise in water table to a minimum by using pipes to continually drain the pond. This simple mechanism requires the installation of 20-cm PVC pipe through the dam with an attached multi-hole intake device guarded by fencing. This method requires little maintenance and is widely used. The Clemson Beaver Pond Leveler was tested at 50 beaver ponds in the southeastern US and was never plugged by beavers, It is easy to fabricate and install, and costs less than $400 per unit. It can be used for culvert protection as well.

Since maintaining biological diversity is a stated NPS servicewide goal, then management actions should be considered that would prolong beaver colonization within the park. In the future, an annual harvest, keeping individual colonies at lower numbers and thereby prolonging the life of the flowage, may be necessary.

FLOODING OF ROUTE 4 VIA OLD CHAMPLAIN CANAL

Because the old Champlain Canal intersects perpendicularly the streams of the park near their mouths, the canal acts as a receptacle for stream discharges (Figure 2). Additionally, the canal captures significant runoff because of its location at the foot of the western terrace of the Hudson River. Primarily in the spring during seasonal rains, these factors act in concert to exceed the hydraulic capacity of the canal. The resulting overflow proceeds down gradient to the Hudson River and ultimately floods portions of Route 4.

While this is an issue of some importance to park because of is importance to visitor protection and safety, it is complicated by the multiple ownership of the canal along Route 4. Any remedial action would probably be for naught unless it was accomplished on all portions of the canal. In addition the Champlain Canal is a historic structure — any remedial action must comply with the National Historic Preservation Act. If the remedial action were structural thereby altering the historic ‘fabric’ of the canal, then extensive deliberations with the State Historic Preservation Officer would be required and mitigation could be costly.

Perhaps the best hope to remedy this issue is for the park to work cooperatively with New York Department of Transportation. The Department of Transportation has initiated a drainage project along Route 4. Enhancing existing drainage ditches or constructing new ones may alleviate the flooding problem by conveying more water away from the canal. This project is underway north of the park and within 2 years work should be commencing along Route 4 in the park.

ADEQUACY OF CURRENT POTABLE WATER SUPPLY SYSTEM

Currently, potable water is pumped from a well (park has two wells but one is no longer functioning) in the Wilbur spring ravine (Figure 5) to the visitor center — a distance of almost 2 miles. Given this distance and the production of the well, pumped water is stored in a 35,000-gallon reservoir in the basement of the visitor center. This infrastructure has been in place for over 30 years and is failing. Leaks in the pipeline are difficult to locate and often times difficult to access due to the depth of burial and the fact that the pipeline right-of-way is not maintained. In some places trees have grown along the pipeline route, creating obstacles for repair machinery. A complete infrastructure replacement is needed; however, the replacement costs combined with the necessary compliance costs under the National Environmental Policy Act for such things as archeology and wetlands put the total cost beyond the capability of the park.

As an alternative, the park is proposing an engineering study for 2001 that will investigate the feasibility of drilling potable water wells at the visitor center. However, the northwestern part of the park is immediately underlain by till (Figure 4). Till contains a relatively large percentage of clay-size and silt-size particles derived from the shale underlying the area. Where the till was compacted by weight of glaciers it is dense and hard to drill through (called hardpan).

Poor sorting and the high clay amounts of the till result in low porosity and a low permeability. Water in usable quantities can be obtained from till only from large-diameter wells which have a large area for the infiltration of water and a large volume for the storage of water between pumping. The sustained yield of wells drawing from till is seldom known because pumps are operated for short periods and draw mostly from storage in the wells. However, based on experience elsewhere in the region, the yield of most wells drawing from till is probably only a few hundred gallons a day.

Underneath the till is a substantial layer of bedrock (Figure 4). Water occurs in the bedrock in openings along faults, joints, bedding planes and cleavage planes. Openings along joints, bedding planes, and cleavage planes tend to disappear or become tightly closed at depth (Heath et al. 1963). Thus the yield of wells is generally not increased by drilling below a depth of about 300 feet unless the lower part of the well penetrates a more permeable formation or a zone in which the bedrock is crushed, as along some major faults.

The yield of bedrock wells depends on the number and size of the openings penetrated by the well. In general the yield of such wells is relatively low. Wells in Saratoga County drawing from the shale have an average yield of 9 gpm (Heath et al. 1963).

Given the apparent hydrogeology of the area around the visitor center, the likelihood of drilling good production wells is low. However, this alternative may still be the most cost-effective. If several, low production wells could be drilled (primarily bedrock based; till based would not be feasible), then they could be pumped for longer periods of time to maintain the capacity of the existing (or larger) reservoir.

Park staff should contact a local well driller to obtain information regarding depth and yield available from bedrock wells. Any driller should have hydro-fracturing services (L. Martin 1995). Hydro-fracturing is a method of increasing the yield of wells in fractured bedrock by overpressurizing the well to enlarge fractures or create additional fractures to intercept a larger pool of ground water.

The park also needs to evaluate its daily use records to determine how much water is needed on both an average and high-demand days (L. Martin 1995). That information, along with the probable yield from a bedrock well could be used to design a water distribution system, including sizing of a storage reservoir.

POTENTIAL RISK OF ZEBRA MUSSEL COLONIZATION

In 1986 larvae of an exotic, freshwater mollusc, the zebra mussel *(Dreissena polymorpha),* were released via ship ballast into Lake St. Clair, Michigan (Miller et al. 1992). In 1991, just 3 years after it was first discovered in Lake St. Clair, zebra mussels were collected in the Illinois, upper Mississipppi, Susquehana, lower Ohio, Tennessee, and Cumberland rivers (Miller et al. 1992; Ludyanksiy et al. 1993). They are confirmed from the upper Hudson River (U.S. Geological Survey 1997). The zebra mussel cannot colonize equally well in the Northeast, in part, because soft water causes ion exchange and reproductive problems when calcium reaches a lower limit of approximately 12 mg/l and pH drops below 7.3 (Whittier et al. 1995).

The rapid spread of this exotic species is of concern to water resource managers because of its ability to cause economic damage (e.g., clogging intake pipes, fouling boat hulls) and ecological change (e.g. major increases in water clarity, impacts on native mussels). Moreover, numerous hypotheses about its potential long-term ecological impacts (e.g. disrupting food chains, destroying spawning beds) have been discussed in both the technical (Nalepa and Schloesser 1993) and popular press.

Zebra mussels are usually no more than two inches in diameter with characteristic zebra-like stripes (Miller et al. 1992). Unlike native, freshwater mussels that burrow in sand and gravel, zebra mussels spend their adult lives attached to hard substrata.

The rapid spread and abundance of zebra mussels can be partly attributed to their reproductive cycle (Snyder et al. 1994). All zebra mussels do not spawn simultaneously. In waters of the United States, larvae can be found from May to October. Native mussels reproduce at a specific time, usually spring. In addition, native mussels usually become reproductive when they are 5 or more years old, unlike the one-year old or less for zebra mussels (Miller et al 1992). A fully mature female zebra mussel may produce up to one million eggs per season (Snyder et al 1994).

Zebra mussels disrupt the aquatic food chain because they compete for the same type of food as fish larvae and other larger zooplankton (Snyder et al. 1994; Hogan 1995). They eat mostly algae in the 15-40 micrometer size range. Each adult mussel, however, is capable of filtering one or more liters of water each day. They remove nearly all particulate matter, including phytoplankton and some small forms of zooplankton. Instead of passing any undesired particulate matter back into the water, zebra mussels bind it with mucous into loose pellets called pseudofaces that are ejected and accumulate among the shells in the colony (Miller et al. 1992; Snyder et al. 1994). This mass accumulation could affect the density and biomass of native mussels, immature insects, and other invertebrates, and cover spawning beds used by stream fishes. In the Hudson River, researchers are discovering that zebra mussels are dramatically impacting both phytoplankton and zooplankton populations, dropping them to less than 20 percent of their normal concentrations (Hogan 1995).

At issue, given the fact that zebra mussels are present in the upper Hudson River, is what is the risk of zebra mussel colonization of other waters in Saratoga National Historic Park? Zebra mussel colonization of park waters could occur via two avenues: introduction through human activities: and, ‘natural’ range extension. The potential for introduction should be assessed from the following risk assessment: 1)Is there an upstream source of the mussels or infested tributaries?; 2) Is there any barge traffic?; 3) Is there heavy boat use and/or a large number of anglers moving boats and equipment from infested waters; 4) Are the boats coming in from contaminated waters?; 5)Is fish stocking occurring in the watershed and what is the source water? 6) What is the source of bait sold at local bait and tackle shops?; and, 7) Are adjacent waterbodies infested (Sue Jennings, St. Croix National River, personal communication)? If the answer to one or more of these questions is ‘yes’, there is a risk for accidental introduction of zebra mussel. From the perspective of Saratoga National Historic Park, the only question that is answered with a ‘yes’ is the last one.

In order for the zebra mussel to extend its range, it needs the appropriate physical and chemical habitat characteristics. For example, if water velocity exceeds 4.9 ft/sec, there is limited opportunity for larvae settlement. Also, if you have backwaters or a lake-like environment (such as behind a dam) then the risk increases. Sustained water velocities greater than 4.9 ft/sec probably occur in the park only during storm events and heavy snowmelt runoff. However, there are no backwaters or lake-like environments in the park. The risk of zebra mussel colonization of park streams is probably low given this risk assessment

Based on the limited data collected by the park’s water quality monitoring program from 1987 to 1990, pH never dropped below 7.3. Calcium was not a measured parameter in the park’s water quality monitoring program, nor was alkalinity which has a direct relationship with calcium (in mg/l) (Whittier et al. 1995). At the Roosevelt-Vanderbilt national historic sites, alkalinity ranged from 52-220 over all monitoring stations in the park (National Park Service 1 997b); this alkalinity range equates to calcium concentrations well below the threshold of 12 mg/l. Calcium concentrations for Saratoga National Historic Park are also probably below 12 mg/l. If calcium concentrations are indeed below this threshold, then park waters, from a chemical standpoint, would not appear conducive for zebra mussel colonization and population growth.

It would not appear that a zebra mussel monitoring program is warranted, given the above discussion. Nevertheless, this pernicious species should not be underestimated. If desired, the park could place monitoring substrates that can be easily removed and examined in the lower segments of Kroma Kill and Mill Creek. Concrete blocks suspended from ropes are frequently used as a monitoring device. A set of PVC plates secured to a rope with a weight on the bottom is a preferred method because the plates have a known surface area and are easy to examine and scrape. Since zebra mussels grow very quickly, they should be recognizable within several weeks of initial settlement.

If zebra mussels are found in park waters, management options are generally limited. However, Saratoga National Historical Park should seek local/regional expertise through participation in cooperative programs or partnerships with federal, state, and local agencies.

FURTHER RECOMMENDATIONS

Most of the important land use decisions made near a protected area involve local elected officials, citizen boards and commissions, and professional planning staffs at the city and county levels, with input from a large number of citizens and other agencies. National Park Service units, overall, have been slow to participate in these planning and decision-making activities in spite of the profound effects that external land use changes are having on their ability to achieve both cultural and natural resource management objectives. With regard to streams and their watersheds, park units whose land base does not include the headwater areas, are either the conduit or repository of water pollution from upstream sources.

There are a number ot ways (listed below atter Wallace, 1999) that park staff can legitimately participate in local land use decisions in order to influence the location, extent, type, and spatial patterns of development near the Saratoga National Historic Park.

- Designate staff to be assigned to work with a wide variety of local government, landowners, homeowners' associations, and nonprofit organizations in order to address adjacent land use issues.
- Conduct a GIS-based boundary layer study with the following layers: 1) a base map showing current land use, infrastructure, ownership, and zoning; 2) a theme showing unique ecosystem components that extend beyond boundaries (e.g. streams and riparian habitats); and, 3) a theme depicting current and potential development activity as indicated by projects under review, ownership characteristics, available infrastructure, quantity of land for sale, and volume of land recently sold.
- A powerful exercise is to model what buildout (the subdivision and development of all adjacent land) on adjacent lands will look like. This can be accomplished by superimposing the infrastructure, development, and use patterns used by built-out developments with similar zoning on top of existing land uses that are not yet built out.
- Participate in the development or revision of the comprehensive (master) plans for the counties and cities adjacent to the park.
- Participate in the development or revision of the land use code for the counties and cities adjacent to the park.
- Propose the creation of an overlay zone near the park.
- Participate in the review of development proposals that could affect management objectives.
- Collaborate with local open space programs and efforts to protect agricultural lands.
- Develop a memorandum of understanding with counties and cities that codifies mutual concerns and how will initiate actions such as those above.
- Use these opportunities to be an advocate of land and community health.

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APPENDIX A

Project Statement SARA-N-014.000
Last Update: 8/20/00 Priority: 1
Initial Proposal: 2000 Page Num: 0001

Title: RE-ESTABLISH WATER QUALITY MONITORING PROGRAM Funding

Status: Funded: 18.00 Unfunded: 30.00

Servicewide Issues: N20 (BASELINE DATA)
Nil (WATER QUAL-EXT)
Cultural Resource Type:
N-RMAP Program codes: 000 (Water Resources Management)
001 (Water Resources Management)

10-238 Package Number:

Problem Statement

Primarily managed to preserve and interpret cultural resources, Saratoga National Historic Park borders approximately 2 miles of the upper Hudson River and contains four 2nd and 3rd order, direct tributaries to the upper Hudson River, two of which have their drainages wholly contained within park boundaries. For example, Devil's Hollow drains a second order stream through hemlock-laden cascades of shale with a drop in gradient of 100 feet. However, the knowledge base for all water resources remains virtually unknown; e.g., surface and ground water quality and quantity and general hydrology; aquatic biology, and wetland species composition and structure. Compounding this lack of knowledge about the park's water resources, is the expected residential and possible commercial growth either adjacent to park boundaries or within two of the tributary watersheds. Potential nonpoint sources of pollution to park waters include: particulates and dissolved pollutants; nutrient loading of nitrogen and phosphorus from municipal and residential wastes; road salt and auto exhaust by-product runoff from roads; gasoline and oil product contamination; and bacterial and infectious agent contamination from septic systems.

The National Park Service (1997) conducted surface water quality retrievals for Saratoga National Historic Park from six of the U.S. Environmental Protection Agenc~s national databases, including STORET. The results of these retrievals for the study area (limits include 3 miles upstream and 1 mile downstream of park boundary) covered the years 1964 to 1994 and included 69 water quality monitoring stations (Figure 10), 15 industrial/municipal discharge sites, three municipal water supply intakes, nine water impoundments, and 33 active or inactive U.S. Geological Survey gaging stations. Most (52) of the monitoring stations are outside of park boundaries, and represent primarily either older one-time or intensive single-year efforts by collecting agencies, or discontinued stations. The data from these stations are of little use in an assessment of current water quality. However, these data do indicate that surface waters within the study area have been impacted by human activities, including industrial and municipal wastewater discharges and agricultural runoff (National Park Service 1997).

Sixteen water quality monitoring stations represent stations located within park. However, data from all 16 stations represent the park's water quality monitoring program initiated in 1987 but discontinued in 1990 due to funding constraints. This limited water-quality monitoring program (Lynch 1987) consisted of 10 parameters measured at 16 stations, primarily over the summer months. Only temperature, specific conductance, dissolved oxygen, pH, and salinity were consistently measured over the 3 years of the program. Nitrate/nitrogen, total phosphate, lead, PCBs, and fecal coliform were limited to 1987 and, with the exception of fecal coliform, were one-time samples only.

While limited, some results of this program do point out potential water quality problems that existed and could exist today. For example, PCBs were present only in trace amounts and fecal coliform often exceeded the EPA standard during the summer months of 1987 on Kroma Kill, Mill Creek, American Creek, and Devil's Hollow.

The recently completed water resources management plan for the park (National Park Service 2000) recommended the re-establishment of a long-term monitoring program designed to provide a more complete assessment of baseline water quality, flag potential degradation resulting from nonpoint source contamination, and periodically appraise the health of the aquatic biological community.

DescrIptIon of Recommended Project or ActIvity

The Saratoga National Historic Park Water Resources Plan (National Park Service 2000) recommends the resumption of monitoring of long-term water quality. The modified water quality monitoring program measures 15 physicochemical water quality parameters on a quarterly basis at nine stations, and conducts rapid bioassessments on an annual basis, following protocols developed by the State of New York (Bode et al. 1995). Other significant modifications include: 1) measurement of stream discharge at gaged stations to determine gage-discharge relationships on all streams; 2) use of a U.S. Environmental Protection Agency certified contract laboratory for all chemical analyses rather than measurement via Hach Kits; 3) analysis of water samples for the

BTEX (benzene, toluene, ethyl benzene, and zylenes) suite ot Purgeable Aromatic Hydrocarbons; **4)** conduct photographic monitoring during quarterly visits to monitoring stations; and 6) develop a water quality monitoring plan to include a quality assurance/quality control program as well as the institution of annual reports that include tabular presentation of data and data analysis and interpretation.

The implementation of this multi-faceted water quality monitoring program will require expertise and laboratory resources extending beyond the current resources of the park. In the short term, the park proposes to work with other federal, state, and local agencies, the NPS Water Resources DMsion, and appropriate local universities capable of providing the necessary field equipment, laboratory resources, and QA/QC protocols for recommended field sampling and laboratory analysis.

Funding requested here is designed to provide additional support to meet annual costs (over the next four years) of the long-term water quality monitoring program recommended in Water Resources Management Plan (National Park Service 2000). The park will gradually assume responsibility of the annual costs over the four-year funding cycle (reflected in following budget). The total annual cost of the water quality monitoring program ($12,000 and 0.1 FTE) will be assumed by the park by the end of the fourth year.

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Budget and FTEs

	FUNDED				
	Source	Activity Fund Type	Budget ($l000s)	FTE5	
2001	PKBASE-NR MON	Recurring		0.00	0.1
2002	PKBASE-NR MON	Recurring		3.00	0.1
2003	PKBASE-NR MON	Recurring		6.00	0.1
2004	PKBASE-NR MON	Recurring		9.00	0.1
		Total:		18.00	0.4

--------------------UNFUNDED------------------------

	Source	Activity Fund Type	Budget ($l000s)	FTEs
2001	WRD	Recurring	12.00	0.0
2002	WRD	Recurring	9.00	0.0
2003	WRD	Recurring	6.00	0.0
2004	WRD	Recurring	3.00	0.0
		Total:	30.00	0.0

Breakdown of First Year Costs and FTEs

Study Activity	FTE	$
Sample Collection	0.03	> 5,000
Data analysis/ management	0.05	
Laboratory analysis of physical/chemical samples		4,000
Biological sampling and analysis		2,000
Annual report writing/ update of monitoring plan	0.02	1,000
	0.10	12,000